Instruments

IE MAGAZINE of MEASUREMENT and CONTROL

Vol. 22 SEPTEMBER 1949 No. 9

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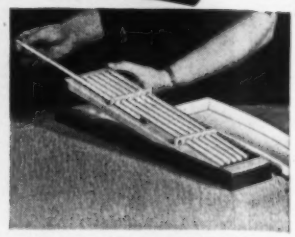

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Win a Prize . . . *and* Help Your Nation
Help Your Nation . . . *and* Win a Prize

THESE are days of tension, when thoughtful Americans KNOW that lasting peace and prosperity could come with just a little effort on the part of mankind, but FEAR that the totalitarians may precipitate a war that would destroy civilization.

These are days of tension within our nation, too, and thoughtful Americans, knowing that "the miracle of production" has been the secret of our success in peace and war, do not like to see a growing percentage of America's total production going down a number of drains — domestic and foreign drains. Nor do thoughtful Americans like to see the "gimme" trends which have been exposed on this page for sixteen years and named in our February and April editorials on "Statism."

Fortunately America isn't licked! She will not be if she boosts her productivity higher and higher. In this progress, instruments will continue to play an important part. YOU are contributing to it by using instruments to cut down human drudgery and at the same time increase production and maintain quality.

Even the Instrument Man who at heart is an altruist, a Boy Scout, a GOOD man, is often constrained to think first of his personal interests before he volunteers to do a good deed. That is one reason why the above title is worded both ways: *Instruments* invites you to enter its Fourth Instrumentation Contest and to share your know-how firstly for your own sake and secondly for the sake of our industries and our national health and strength (or in the other order).

The articles resulting from this contest will appear in the earliest possible issues of *Instruments;* also some of them will be printed in a number of other periodicals — wherever they will spark-plug the adoption of the latest methods of boosting productivity.

Every reader who knows of one or more ways of using instruments to cut costs is urged to enter the contest. The rules have been made easier than in our previous contests. Brief entries will be examined as carefully as lengthy ones. It isn't as hard as you think! Read the rules and start preparing your entry!

* *

Announcement and Rules of the Fourth Instrumentation Contest

SPONSOR: The Instruments Publishing Co., Inc.

THEME: "Instruments Cut Costs."

PRIZES: First Prize, $200; Second Prize, $100; Third Prize, $75; Fourth Prize, $50; three Fifth Prizes of $25 each.

ENTRIES: Each contestant is to submit an original essay, report, dissertation, etc. (hereinafter termed an "entry") bearing upon the Theme of the Contest.

"Instruments." The device or apparatus whose uses are described may be anything from a simple gage to a complete installation of interlocked and coordinated process controllers. Automatic-gaging, automatic-testing, and automatic-inspection set-ups, likewise, are suitable subjects. So are meters. So are electronic devices and many useful "gadgets."

"Report." This type of entry may briefly describe a single case and be written in telegraphic style; or it may present detailed statistics covering a twenty-year period; or it may analyze a whole industry. In this type of entry the data—the numerical "scores"—count more than the style of writing. An entry consisting of charts and tables—with only one paragraph of text—would be acceptable. This "graphic" type of entry is the easier to prepare by entrants who have already gathered statistics or who can gather them.

"Essay" (limit, 1000 words). In this type of entry, the manner of presentation must make up for the possible absence of statistical data; but FACTS must be presented. Wherever exact figures are difficult to obtain, case-studies must be analyzed in sufficient detail to support the conclusions.

"Reports" should not be padded with a number of charts and tables copied from books, journals, etc. available to the public; pertinent abstracts suffice. "Essays" must not exceed one thousand words. Brevity and conciseness will count in grading all entries.

SEVEN PRIZES	
First Prize	$200
Second Prize	$100
Third Prize	$ 75
Fourth Prize	$ 50
Three Fifth Prizes . . .	$ 25

Each contestant may submit as many different entries as he desires.

Entries need not disclose new and patentable instrument ideas; what you are doing with known instruments may be new and widely useful.

Authenticity: Source of data should be given. Manuscripts made up of assertions, figures, charts, etc.—even the most impressive—risk being disqualified if the facts and figures are not supported by references to authentic sources, or are not otherwise verifiable. After the sessions, all manuscripts receiving Prizes or Honorable Mentions will again be checked for accuracy and authenticity before the list of winners is made public.

All "essays," and all textual portions of "reports," must be typewritten, with lines double-spaced or triple-spaced, on one side of the sheet. All charts and other drawings must be in India ink on white paper or clean tracing cloth, suitable for black-and-white reproduction. (No pencil-shaded areas or other treatment that would blur.) Hand-written and single-spaced typewritten essays will not be considered. All entries must be addressed to **Contest Editor, Instruments Publishing Co., 921 Ridge Ave., Pittsburgh 12, Pa.**

The Judges' ratings will be based upon: pertinency of factual data (closeness to the theme); value of information presented (breadth of applicability to problems faced by various industries); timeliness, novelty, originality, etc.; and effectiveness of presentation.

Manuscripts and illustrations become the property of the Sponsor and are not to be returned. The Sponsor reserves the right to publish any article submitted, whether prize-winner or not, and to exercise the privilege of editing each manuscript. Most will be published in *Instruments;* others—especially those of interest to specific industries, in special-scope magazines. Due credit will be given to the author of any article which is published after the selections are made.

Contest closes Saturday, December 31, 1949. All entries must be in the office of The Instruments Publishing Co. on or before that date. Don't forget that the envelopes must be addressed to "Contest Editor."

Plant Instrument Shop Testing Equipment*

By HART U. FISHER, Monsanto Chemical Co., Monsanto, Illinois

INDUSTRIAL plants vary from the smallest operation to a complex integrated series of continuous processes. Many of the smaller plants cannot have an instrument department but have a handy man as instrument man as well as pump man, electrician and whatever else is required. He very likely has a little shop and among other test apparatus he has the kind of equipment he needs to make sure that the instruments are performing satisfactorily. Or maybe he is a fellow who is such a good egg that he can call the local representative of the instrument company and borrow the testing equipment needed. And when the representative brings it over he might have time to take a look at the instrument and see what he thinks about it. In any case the small plant can use the information presented in this paper if they so desire. Some will and some won't.

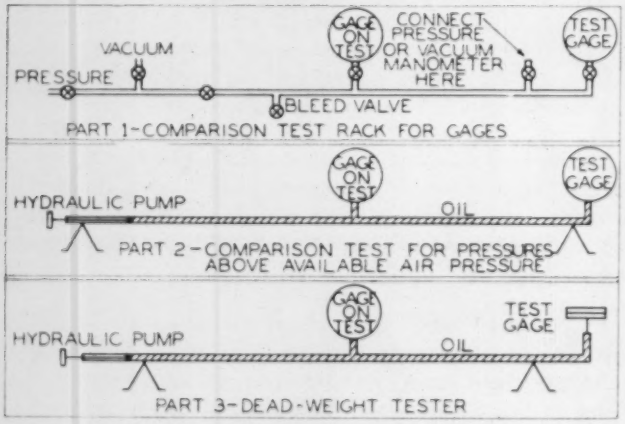

FIG. 1- PRESSURE GAGE TESTING

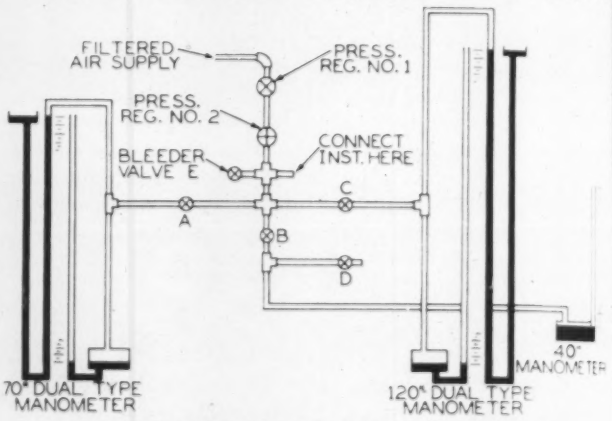

FIG. 2-DIAGRAM OF 3-MANOMETER HOOK-UP FOR LOW-PRESSURE OR DIFFERENTIAL-PRESSURE TESTING

The rest of the industrial plants have a problem which they may or may not recognize. The selection of delicate measuring instruments which are available today should consider the facilities of the plant from the standpoint of checking and maintaining the instruments at a suitable accuracy. An instrument which is accurate to 0.1 C. needs a standard in the plant precise enough to prove the accuracy of the device. Many such claims are made because the seller knows that the user cannot prove or disprove the claim. If that is the case the instrument is not needed.

Most measurements which are used in plant instrumentation can be checked or compared with a standard. In many cases the standard need not be expensive or elaborate. Although a platinum bar is located in the Bureau of Standards which serves as standard of length, most of us get by very nicely by using a 6-foot rule which we buy at the dime store. In the same manner rather inexpensive base-metal thermocouples can be purchased from any of the companies who manufacture thermocouple type instruments with Bureau of Standard certificates giving the accuracy of the couple throughout its range. This permits the user to establish the thermocouple as a secondary standard and, if properly cared for, it will serve as such for a number of years. Some use these thermocouples only to periodically check the test ones in regular service.

Many plants make their own thermocouples. The wire, if bought from a reputable supplier, will test within 5 F. when made into a thermocouple. Each batch of wire can be checked as thermocouples are made at some temperature near where it will be used. The secondary standard thermocouple is used with a portable potentiometer whose range is 0-60 millivolts. Care should be exercised in checking, especially at high temperatures, that the two thermocouples, one standard, other being checked, are at the same temperature. The tester should also fully understand the portable potentiometer being used so that errors due to cold junction compensation do not occur.

Thermocouples which are used in relatively low temperatures can be checked by National Bureau of Standards certified mercury thermometers. If an oil bath is used as a means of varying the temperature, a very good check can be obtained.

Bulb types of temperature instruments can be checked in the same oil bath. The unit must be one which closely holds an oil temperature when checking. If two pots are available and each is maintained at a fixed point, calibration is simplified. One is generally held at one-third scale and the other at two-thirds scale. A bucket of water at or near room temperature can sometimes serve as one point, if only one oil-bath pot is at hand. Care must be exercised, in any case, so that you have good agitation of the heating medium and complete submersion of the bulb.

Many plants have bulb type instruments with bulbs located where bath calibrations are difficult to make. There is one plant that solders the thermocouples on the bulbs and runs the lead lines to an accessible spot near the recorder. A fair check can be made with portable potentiometers because it is not likely that both tube systems and thermocouple will go bad at the same time. If corrosive gases are prevalent in the area, however, they might cause erroneous thermocouple readings.

For very high temperature work the optical pyrometer is used. Its reliability is dependent to a marked extent on the operator, and believe me they vary. Steel mills use them and seem to manage very well. A steel mill instrument man says:

"In the case of testing an optical pyrometer, precision instruments are required. In fact, the following are used: (1) A flat tungsten filament lamp that has a notch cut into the filament at the hottest point, on which the optical telescope is sighted; (2) A standard shunt in series with the lamp filament; (3) A precision potentiometer connected across the shunt; (4) Necessary rheostats to control the current from a 12-volt battery; (5) A standard optical pyrometer calibrated by the National Bureau of Standards in Washington to check the lamp."

The test assumes that a definite temperature exists in the filament of the lamp when a known current flows through it. The potentiometer measures the current by accurately determining the voltage drop across the filament or shunt. The standard optical makes certain the lamp is correct by measuring the filament temperature once per month.

A refinery instrument man once said, "I can measure the temperature of a block of ice with an optical pyrometer. Its temperature by so doing is 720 F."

The operator has lots to do with the reading of an optical pyrometer and

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Note:—Statements and opinions advanced in papers are to be understood as individual expressions of the authors and not those of the Society.

the fact that the object under observation for temperature must be under blackbody conditions was overlooked by the refinery man. Blackbody conditions are defined by the National Bureau of Standards as follows: "An object is said to be under blackbody conditions when it is completely surrounded by other objects, all of which are at the same temperature." The block of ice does not fulfill these requirements and therefore any reading taken by an optical pyrometer would not be accurate.

Three ranges are available, 1400 to 2200 F., 1950 to 3200 F., 2700 to 5250 F.

Pressure standards are dead-weight testers from 15 to 10,000 pounds generally. For low pressures it is desirable to use well type manometers. Vacuum or below atmospheric pressure standards can be either open manometers used with a mercurial barometer, or a closed-leg absolute-pressure manometer. Inclined-tube manometers are helpful for small vacuums or pressures of two inches or less.

Well type manometers must be checked frequently for zero reading. In fact, each use to which it is put should start with a zero reading.

Dry- or gas-pressure gage calibration is necessary in case of oxygen gages or helpful in testing gages used on corrosive service such as dry chlorine gas. A test rack diagram shown in Fig. 1, Part 1, can be used for this purpose. Standard gages should be 6-in. size of Test Gage Quality. Ranges can be selected to fit the individual plant's requirements. Dry air is suitable for pressures up to 80 lbs. in most plants, and nitrogen from cylinders is convenient for higher pressures.

Longer gage life on corrosive gas service will be experienced if all calibrations are made with dry gas rather than a dead-weight tester. In specifying the gages on purchase this condition can be satisfied. Some manufacturers insist on a dead-weight test but when this is the case the specification should require that all fluid be removed from the Bourdon tube with a suitable solvent and that the gage be shipped dry and clean.

Part 2 of Fig. 1 indicates a method of comparing gages where high pressures are desired or where a dead-weight tester shown in Part 3 is not available. It is less expensive than a dead-weight tester and it may be more convenient. Some shops make a manifold on which a number of different range test gages are mounted.

The dead-weight tester is often mounted permanently and a large wheel mounted on the ram to make its use more convenient.

Differential-pressure instruments used on flow, low-pressure and level measurements are most easily checked by dry calibration using well type manometers and air from the dry air supply in the shop. Fig. 2 shows a simple manifold arrangement of three manometers each filled with water and the up reading scale can be observed from 0 to 60 inches while the range from 60 to 120 inches is read on the down reading scale. In this way the mechanic can sight the level without climbing on anything.

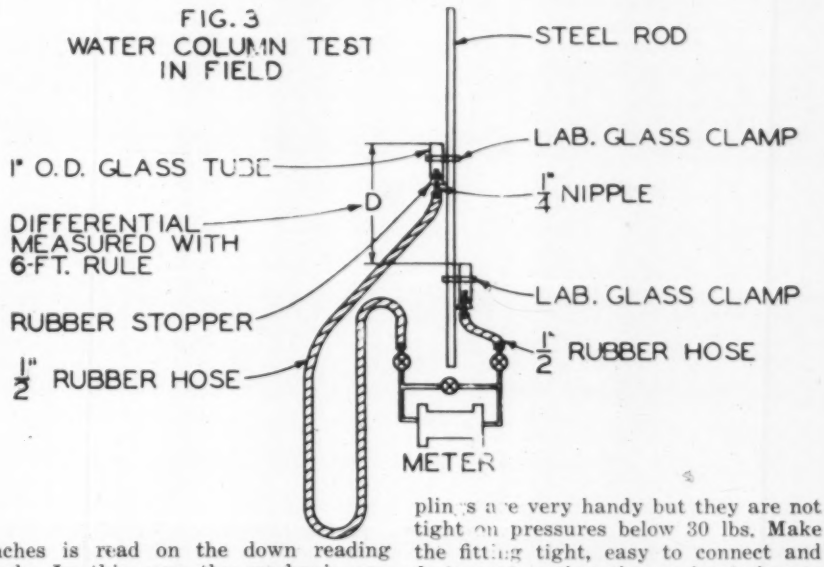

FIG. 3
WATER COLUMN TEST
IN FIELD

The second manometer is a dual 70-inch instrument which is generally filled with acetylene tetrabromide whose specific gravity is 2.95. Pressures up to 200 inches of water can be observed on this manometer which should also have both "up" and "down" scales for ease of reading.

The third unit is a single-tube 40-inch well-type manometer. Mercury is the fluid most often used in it because it is an excellent pressure gage to calibrate pneumatic transmitters or receivers.

All three manometers should be made of stainless steel so that any of the three fluids can be used in any gage. This makes a completely flexible set-up for pressures from a few inches of water up to 1500 inches when mercury is used in the long manometer. Some of the new force-balancing transmitters, aneroids, and differential-pressure cells have ranges from 600 to 800 inches today. A year or so from now the differentials may be as high as 1500 inches and this stand will be ready for them.

A differential transmitter can be checked with two of these manometers. One can measure the differential imposed on the transmitter while the other can show the transmitter output pressure.

Notice the valving. Use good quality bar stock valves which will shut off tight and not leak through. Valves should be plentiful enough to make the unit flexible but not complicated. There are many arrangements and each shop should develop their own to satisfy their needs.

Tubing for connecting instruments to the apparatus should be quite flexible and quickly connected without possibility of leaks. Copper tubing such as is generally used in permanent installations of air-operated instruments is too stiff and repeated use develops kinks and leaks. High-pressure rubber hose such as that used on oxy-acetylene torches is fine but a suitable connector must be provided. Snap-connector couplings are very handy but they are not tight on pressures below 30 lbs. Make the fitting tight, easy to connect and fool-proof so that the mechanic has to spend the least possible time getting set to run his test.

The double pressure regulator arrangement is provided for convenience to the mechanic. The first regulator is a standard instrument regulator which is rather inexpensive. For most water column tests the setting of this regulator is 10 lbs. Final adjustment to read on the manometer is made with the second regulator which should be a better unit. The best small volume regulator obtainable should be installed on this service.

The valving in Fig. 2 is simple and compact. Only one of the valves A, B, or C is open, depending on the manometer selected as the standard. The valve D has two uses. In one case it acts as a vent valve when open and valve B is closed. A vacuum system is connected to the top of the 40-inch manometer when a vacuum instrument is checked.

The bleeder valve should be a fine needle valve of small capacity.

Some differential measuring instruments should be tested in place and with water on the mercury (or in the meter bellows in the case of the mercuryless type.) A special set-up is necessary for this and it should be compact and portable. Fig. 3 indicates one type of water column test set-up which is convenient and portable. It is quick to set up and easy to operate.

The pressure connections to the meter are removed at the meter manifold valves. A nipple is screwed into each valve and the half-inch rubber hose slipped on them. The hose must be properly sized to fit snugly on the nipples, and it must be large enough to allow the tester to easily work out all the air in the hose when it is filled with water. The steel rod is bolted in place or securely supported in some manner and it must be long enough to permit D to vary up to the maximum of the meter on test. The upper end of each hose is connected to a nipple run through a glass stopper which is placed in the bottom of a 1-inch O.D. glass tube about 6 or 8 inches long. A common laboratory

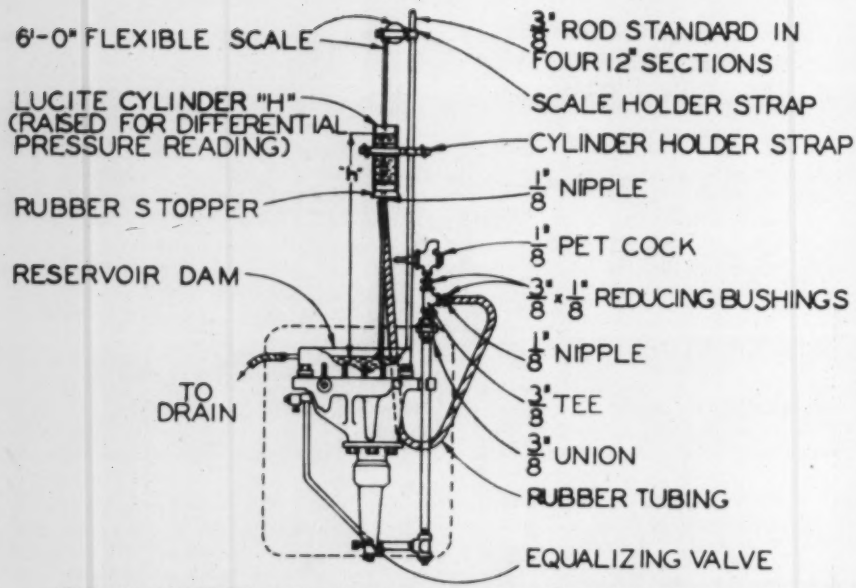

FIG. 4 - WATER COLUMN TEST ON LEDOUX BELL METER

glass tube clamp holds the 1-inch O.D. tube in the desired position to check a differential.

If neoprene hose and stoppers are used, a calibration can be run using a medium other than water in the manometer, but consideration must be given to the different gravity of the liquid. In the bellows type meter this may be of consideable value because it will be impossible to get a reliable test if all the air is not removed from the convolutions of the bellows. Therefore, when the bellows is properly filled, the test will indicate it and no drain and refilling will be necessary.

Another portable test rig, shown in Fig. 4, is used only on the Ledoux-bell type of instrument. The calibration is run with the dome of the bell removed and replaced with a "dam." It makes the whole job easier and faster. The special dam can be obtained from the meter manufacturer. The four-section rod is mounted right on the meter body and the sections screw together. The clamps are similar to the ones in Fig. 3 and permit the tester to set the water column wherever he desires. With the top of the bell casing removed while running the calibration, adding or subtracting weights or mercury can be done without taking the meter apart.

Calibration tables for the different ranges of flowmeter manometers used in the plant, mounted betwen clear plastic sheets for protection and placed where the tester can conveniently see them while making a calibration, are helpful. Mistakes can be made if the mechanic is required to calculate the various check points for his calibration especially if a uniform chart is used on the instrument being calibrated to record flow-rate. In case of an instrument which employs a square root chart, it is generally possible to use a correct-range uniform chart to assist in calibration. If the manometer range is odd so that a uniform chart does not correspond, the table should be available just as in the first case.

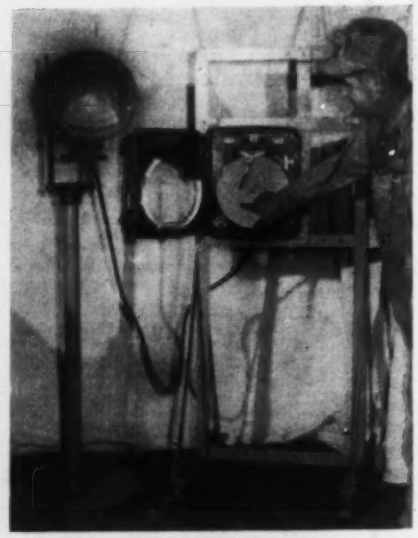

Fig. 5. Instrument Rack and Stand.

Instrument racks for transmitters and recorders are shown in Fig. 5. The stand for yoke-mounting instruments has a 20-inch base with three leveling screws. The seemingly large base is necessary to make sure that it doesn't topple over with an instrument mounted on it. It is round so that it can be easily rolled around the shop and used wherever desired. Recorders can be mounted on the square-frame rack which is built so that any size of rectangular case can be mounted on. The bottom cross-member can be moved up or down to suit, or the side members can be moved to right or left. Portability is provided by sturdy casters, two of which have brakes to hold the stand when in service. An instrument mounted on this rack can be rolled to the workman's bench where rewiring or any form of repairs can be made. It eliminates the necessity of improvising a support for the instrument which many times mars the case.

A home-made mercury handling table is quite convenient to have in a shop where a considerable quantity of mercury is handled. Fig. 6 shows a sketch of such a table. A steel top table with a rim built all around the sides about one inch high keeps the spillage from running off on the floor and being lost. A section of 6-inch pipe about 12 inches long with a welding cap in the bottom of it will hold a 75-lb. flask of technical grade mercury. Three legs can support this container on the table which is about 18 inches square, high enough above the table top to allow a valve and some kind of beaker to be placed under it. A small air hose stuck into the mercury for agitation will roll the mercury around enough to float all foreign matter to the top and allow good clean mercury to be drawn off the bottom.

Mercury removed from meters or manometers will possibly be dirty. It can be placed in the container and, after agitation, the mercury is quite satisfactory to re-use. If it is too bad, it should be washed with nitric acid and many plants would prefer to have this operation performed by their laboratory.

Mercury is expensive and some hazard in the shop. Both should be considered in plans for handling it. Meters

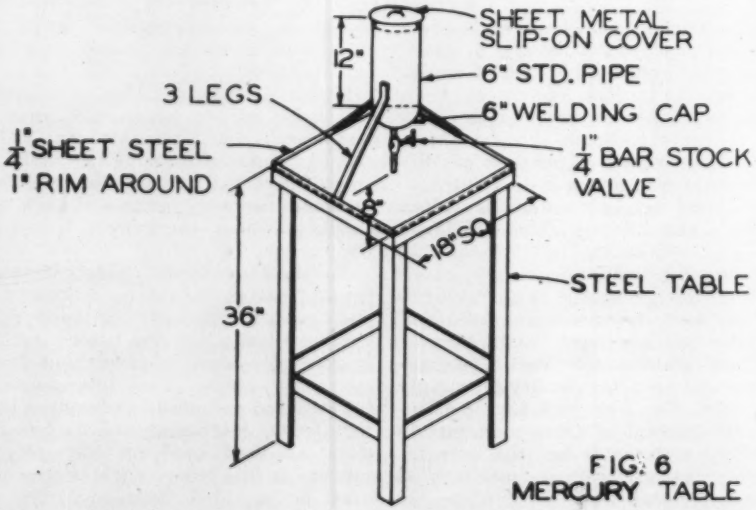

FIG. 6
MERCURY TABLE

can be filled in the shop with metal pans placed under the meter when the filling operation is being done. The spillage is then not lost nor does it run into cracks in the floor or work-benches and lead to a health hazard of workmen breathing the vapors.

Positive-displacement meters can be tested, if the flow-rates are not too great, by running the fluid through the meter under test and into a container on a scale. By converting the weight of the fluid into volume units, such as gallons or cubic feet, a check with the meter register can be made.

Rotameters can be checked in a similar way but a stop watch is required to enable the tester to know how to compare the weighed fluid with the rotameter reading. A swing joint in the pipe line at the scale makes the switch easy at the time the stop watch is started. Good regulation of flow will make the test more accurate, otherwise the man running the test will have to try to average the rotameter reading during the time the sample to be weighed is flowing.

There are two types of electrical instruments needed in most shops. One type is portable and is available for both shop and field work. The other is only used in the shop.

The 0-60-millivolt portable potentiometer is one of the portable test instruments. It is generally the first piece of test equipment needed in an instrument department, especially if there are any thermocouple type instruments in service. In most models of this instrument two ranges are provided: 0-16 and 0-60 or thereabouts. Higher range is needed in checking pH potentiometric installations. A dual-range instrument, 0 to 0.111 volt and 0 to 1.11 volt, can be used for this purpose. Standard cells can be checked with this instrument.

In the case of need for high-precision checking for research work, the "Type K" potentiometer is almost a recognized necessity. It has a very long slide wire and a galvanometer which reflects a beam of light onto a scale to magnify its movement.

A good Wheatstone bridge, with a decade resistance box, is helpful if it ever becomes necessary to make a fixed-resistance coil for emergency replacement. Small shops are not always expected to do this sort of job but it could really get you out of a jam some time when a coil burns out in one of the important instruments. Spare parts are rather hard to justify in such an emergency because its chance of happening is very remote.

Electronic type instruments are becoming quite common today and special equipment is necessary if repairs on them are to be made. A volt-ohm-milliammeter will help in many cases. There are different makes available and the individual selecting can determine best what to buy. Some may want to build their own. Many of the plants will have two of these instruments, one for portable use and one for shop use. The shop one may be more elaborate than the portable one.

A tube checker is recommended for a shop employing two or more men servicing electronic devices. The emission type of checker is recommended so that some indication of tube performance can be obtained.

The new small battery testers are excellent in plants where considerable quantities of batteries are used. A monthly check with this unit of all the batteries in storeroom stock keeps the stock in good shape and saves many return trips to the storeroom. There are built-in load resistors which simulate the operating load of a battery under proper conditions.

A special instrument is required if capacitors in electronic circuits need to be checked. It is a capacitance bridge and is quite useful for capacitors used in the ballistic-galvanometer circuit of the glass-electrode pH instrument.

Portable test instruments must be carefully handled and issued to mechanics. It is best if some individual is charged with the responsibility of keeping the test apparatus in proper order and knowing where it is. This job includes changing batteries, ordering spare parts and repairing the instruments when needed. He should devise a method of issuing shop instruments so that anyone can know where they all are at any time. This is necessary because the shop instrument man may be absent because of illness or vacation, or any of many reasons, and the work must go on.

Here again the shop foreman should provide convenient test arrangements so that workers are not required to improvise hook-ups. Have an adequite supply of connecting leads all made up, some with plug-in fittings for jacks and others with clamp fittings where jacks are not provided. The shop man should inspect the leads at regular intervals and replace faulty ones.

A portable two-pen pressure recorder is quite helpful to the department as a whole in a fairly large plant. There are always locations in the plant where steam or water pressures give trouble. The portable gage can be connected for a few days or weeks and a study made of the pressure variations. If flowmeters are installed on the lines, it is quite possible that correct piping changes can be recommended to correct the trouble. If a flowmeter is not available, it may pay to install a portable one to give a coincidental record with the pressure recorder. A portable flowmeter for this kind of service is frequently one with a complete set of range tubes, from 10-inch to 400-inch. Most conditions can be met in this span. The second pen has a low range. One from 0 to 25 lbs. is adequate and its use is mainly for studying performance of pneumatically operated automatic controllers. A two-speed clock, 24-hour and 96-minute, of the spring-wound variety, is suggested. Money is saved by using a spring-wound clock and thereby eliminating electrical hook-up. However, if 110-volt outlets are plentiful and safe everywhere, it would be desirable to provide a 40- or 50-foot extension on the instrument which could be plugged in conveniently. Two speed clocks, 24-hour and 24-minute, are then available.

The fast speed is helpful when a controller is new and the instrument engineer is studying his adjustments. A graphic picture such as a chart record, will often help solve the problem and save considerable time. The 24-hour speed of chart is always used when overnight performance is recorded. There are certain conditions which occur unexpectedly and cause the operator to put automatic controllers on manual. Record of the performance of the controller at this time may help solve your problem.

A plant instrument department must not only be able to check the accuracy of instruments used in the plant, but must be sure that they are being used properly. Many times I have noticed that an instrument is not relied upon even after its accuracy has been established by people who know it backward and forward. Sometimes the temperature element is not located in the main fluid stream and although the temperature shown on the recorder is exactly correct, it will appear wrong to the operator. The finest test apparatus in the world will not correct the situation and, for this reason, I feel that the process engineering must not be neglected to the detriment of the best of mechanics or test equipment.

The manner in which test apparatus is used is a big factor. It should be as simple as it can be; it must be convenient to use; and the mechanics must have adequate training to correctly use it. There is no set rule for doing these things. The type of industry, the size of it, and the people involved require each man who must care for instruments to plan for his needs. A few ideas have been given to assist in his thinking of the problem but modifications must be made to suit the individual situation.

Test equipment in most instances is not delicate but it must be cared for and used with discretion. Complete instruction should be easily available for the use of any or all apparatus.

In 1945, in London, at the annual meeting of the Institute of Chemical Engineers of England, a joint conference on instruments for automatic control was held. Sir Frank Smith, chairman of this conference, remarked in his opening address, "Nearly every big advance in indutry is the result of knowledge obtained in the first phase by the use of a new instrument. Those who have studied the history of the steam engine know that it was the indirect result of a study of the barometer. . . . By the inventions of new types of instruments one obtains new knowledge and that new knowledge often leads to a new industry."

These comments should make those of us in the field of instrumentation feel that we are in an enviable position. The testing and calibrating of instruments are of utmost importance and extremely vital to industry.

Characteristics of Hair-element Humidity Instruments

By MAX F. MUELLER, Chemical Engineer, Baltimore, Maryland

A PROJECT involving the obtainment of psychrometric data from more than a thousand long-term tests in locations scattered throughout this country, the arctic regions and tropical Panama, necessitated the accurate measurement of the water content of air at a reasonable cost. An undertaking of this magnitude was entered upon by the author while engaged in work under contract to the Ordnance Department of the U. S. Army.

More than a thousand containers, varying in volume from 7 cubic feet to 14,000 cubic feet, were under test at these outdoor exposure sites which presented practically every climate and weather condition likely to be encountered in normal storage conditions. To evaluate the conditions inside these containers it was necessary to measure the relative humidity of the atmosphere in each container.

Humidity and temperature measurements taken in connection with psychrometric problems must be reasonably accurate if the data so obtained are to be of value. The simplest accurate method of determining the relative humidity of a sample of air is to measure its dew-point temperature by means of a manually-operated dew-point cup. The dew-point temperature so obtained is a direct function of the moisture content of the air sample (specific humidity). When the dry-bulb temperature is known, the relative humidity may be obtained from psychrometric charts or tables. Unfortunately, a dew-point cup is tedious to operate for any extended period of time and its use would have required an excessive number of technicians working at all hours to obtain enough readings.

The most widely used humidity-measuring device is the inexpensive hair-element indicator in which a bundle of human hairs shortens or lengthens with changes in the relative humidity of the surrounding atmosphere, thereby causing a pointer to move up or down a scale. If these instruments could be relied upon, here was a simple answer to the problem of obtaining data from a thousand tests at a reasonable cost.

It is well-known that hair elements have a serious time lag when subjected to changing humidities, and that at very low temperatures they are almost insensitive. Furthermore, hair-elements hygrometers require frequent adjustment. Nevertheless, the human-hair assembly still remains the most generally used hygrometric element by virtue of its low cost. The purpose of the tests herein reported was to evaluate hair-element instruments: to determine what degree of accuracy might be expected from them, how frequently readjustments had to be made, and how their operation might be improved to serve in the best possible way the purpose for which they were to be used.

Test Set-up

A glass door was installed in the front face of a test container of some 3420 cubic feet in volume; and four humidity indicators were placed behind the glass in such a manner that the indicating scales could be read from the outside. This container depended upon the changing ambient weather to produce a variety of temperatures and relative humidities in which to test the instruments.

An extremely sensitive and accurate dew-point temperature and dry-bulb temperature recorder was installed, with the sensing elements placed in the same plane in relation to the front wall of the container as the instruments to be tested. In this way, the true relative humidity could be calculated at the test point at any desired time. Frequent checks of the control instrument were made throughout the tests by means of a dew-point cup to assure that the calculated true humidity was at all times accurate. (Although this recorder is extremely sensitive and accurate, its cost prohibits universal use in large numbers.)

In order that frequent periodic readings of the instruments might be taken at all times without requiring constant attendance by personnel, a device was designed and built to photograph the test instruments at the desired intervals. This device consists of a series of timing cams and Mercoid switches which operate a robot camera to photograph the test instruments. Three principal Mercoid switches fulfill the following functions:

As the first one makes contact, a photo floodlight focussed on the test instruments is turned on;

The second switch makes contact a few seconds later and energizes a solenoid which drives the lever arm that operates the robot camera, thus taking the desired picture;

The third switch turns off the device, causing the photo floodlight to go out and the lever arm to release the button on the robot camera which in turn causes the film in the camera to be wound around to the point where it is ready for the next picture.

This series of actions may be produced every fifteen minutes if desired, by cams which are driven by a synchronous timing motor. An additional cam, having one notch, rotates once an hour; still another, which has eight notches, rotates once every 24 hours. By a dummy cam attached to the 24-hour cam, any desired combination of these notches may be blanked off. In this way the device can be operated to take pictures at 15-minute, 1-hour, 3-hour,

Fig. 1. Hourly pictures are obtained of the humidity-indicating scales. (The laboratory thermometer was used only at first as an additional check.)

6-hour, 12-hour, or 24-hour intervals. The entire camera and timing device is mounted in a wooden box and the picture is taken through a square hole in the front of the box. Fig. 1 shows the type of picture obtained every hour during the tests of the hair-element indicators. Thirty-two instruments were eventually tested for long periods of time by this method.

Discussion of Test Results

Characteristic results only are shown in the accompanying graphs, since the plotting of all data would produce a somewhat bulky record.

False readings are usually obtained from hair-element instruments when they are placed in use for the first time, as illustrated by the Fig. 2 curves. The true relative humidity in the test space is represented by the lower curve, points being plotted at two-hour intervals. The upper curve shows a typical result obtained from a newly-purchased hair-element indicator, supposedly adjusted at the factory. Owing to vibration during shipment and rough handling, the great majority of these instruments produce erroneous initial results as shown. The indicator curve lags the true curve, although at first glance the two appear parallel.

Fig. 3 illustrates the typical curve obtained from a hair-element indicator after it has been adjusted. The lag behind the actual condition is evident and the hair-element indication never quite reaches the true peaks and valleys. A fair daily average humidity would be obtained with this instrument but spot readings would be subject to plus and minus errors. Further tests with these instruments show that even after they are placed in correct adjustment, the indication creeps with time, usually after several months, and periodic readjustment is mandatory. Spot checks against accurate humidity devices, such as a dew-point cup, are worthless, and correction can be made only after a series of check values are obtained over a complete cycle of operation, where the relative humidity varies through a considerable range.

All instruments, regardless of cost, which depend on hair-elements for humidity sensitive elements, have these characteristics. Fig. 4 shows typical results from humidistats. A humidistat is a controller for dehumidification or air-conditioning machinery: as the hairs lengthen with increased humidity they close an electric contact, which in turn operates the machine. They may be adjusted so that this contact takes place at any desired level of relative humidity.

Since ordinary humidistats have no scale which indicates the relative humidity at which they make or break contact, a modification had to be made in the test method. The robot camera was replaced with an operation recorder on which a series of pens draws circles on a 7-day chart. Each pen is moved by a magnet in such a way that, when the humidistat connected to it makes contact, the magnet will move the pen and offset the circle being drawn. When the humidistat opens and contact is broken, the magnet releases the pen, which then returns to its original position. The true humidity in the test container is then determined from the dew-point and dry-bulb temperature, as described above in the discussion of the humidity indicator tests.

The results in Fig. 4 are characteristic of some 48 instruments tested. The humidity in the test space is shown by the lower curve. The interrupted curves, A and B, represent the humidistats, each being in contact for the length of the line, the gaps representing the time during which they were not making contact, and the figures showing the percent relative humidity at the time of make and break. Both humidistats were adjusted together. Note that A broke contact at 23% RH and made contact at 25% RH, while a few hours later it did not break contact until the relative humidity fell to 20% and then came on again at 23% RH. A machine would operate for longer periods of time if activated by humidistat A than it would if attached to B.

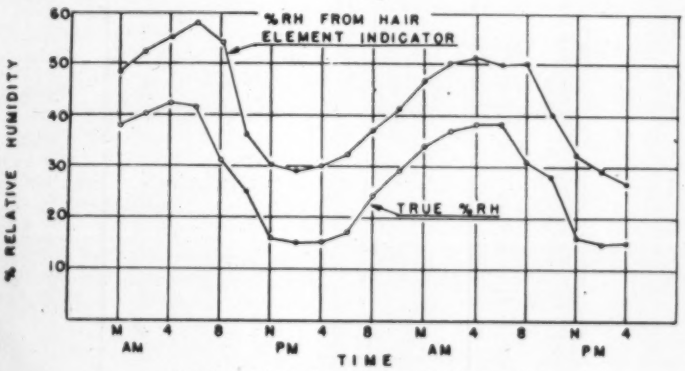

Fig. 2. Initial indications may be inaccurate.

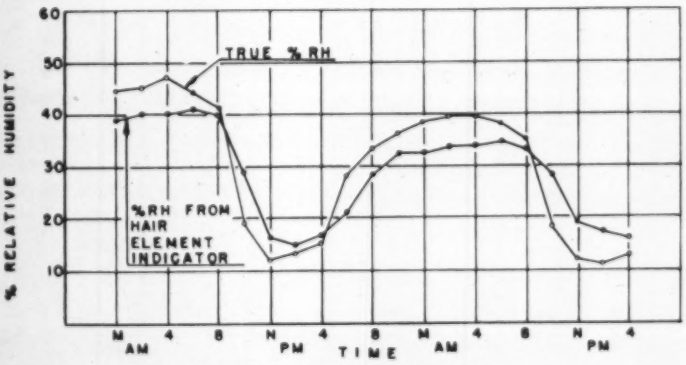

Fig. 3. Hair elements tend to lag slightly behind.

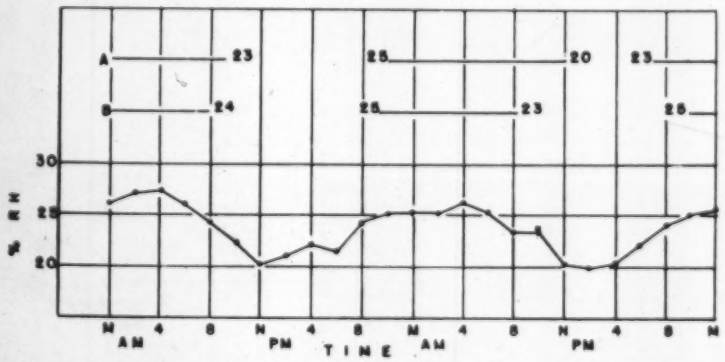

Fig. 4. Humidistats make and break contact close to the preset conditions.

Conclusions

In general, instruments are received from the manufacturer in correct calibration for the range in which they are expected to operate. This does not apply to those humidity instruments depending on the human hair for their sensing element, owing to its proclivity for getting out of adjustment during the amount of vibration normally received during shipment and handling. The most annoying characteristics are initial false readings, lag and creep.

However, if these instruments are checked and adjusted before use and rechecked at frequent intervals, acceptable results may be obtained and, owing to their low cost, these instruments are applicable to a wide range of problems. A lack of understanding of their characteristic, however, makes their indiscriminate use of uncertain value.

Acknowledgement is made to the Army Ordnance Department, under whose authority this work was accomplished.

Fig. 1. Oscillograph with tube and film drive in place.

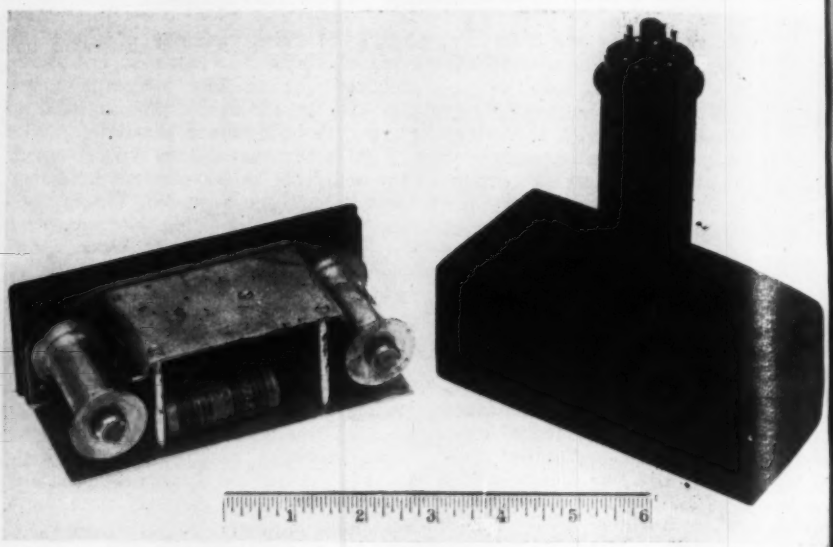

Fig. 2. The oscillograph with film drive removed for loading.

A Miniature Portable Cathode-ray Oscillograph Recorder

By CARLTON F. JOHNSON, Ordnance Research Laboratory,
The Pennsylvania State College, State College Pennsylvania

MODERN field test equipment frequently necessitates the employment of instruments and circuits which must fit into unusually small spaces of irregular shape.* In satisfying this requirement a portable cathode-ray oscillograph recorder has been constructed with the smallest possible dimensions consistent with its conditions of use. Although size and shape of the device were dictated by specifications peculiar to its use in a particular connection, its principle of construction can easily be adapted to other forms.

The instrument consists of a one-inch CRO tube (RCA-913) and a readily removable paper drive mechanism, both enclosed in a light-tight sheet metal box 2 in. by 2.5 in. by 5 in. (Fig. 1). The box is fabricated of light-gage sheet steel with welded seams. One of the longer sides of the box is open and receives a Bakelite door which is stepped to provide light sealing. Permanently bolted to the Bakelite door are the paper drive mechanism and binding posts for the paper drive motor leads. The paper take-up spool is driven by a six-volt permanent-magnet-field motor through reduction gearing (Fig. 2). A brass tube about three inches long is silver-soldered to the top of the box. The CRO tube is held in place inside the brass tube by means of a snugly fitting felt sleeve which also serves as a light seal and as electrical insulation. When in position, the face of the tube is directly in contact with the recording paper. About ten feet of single-weight recording paper 1.75 in. wide can be accommodated by the paper drive.

The tube is operated at from 250 to 300 volts obtained from a single Eveready No. 493 dry battery. The battery also supplies the plates of a high-gain audio amplifier, and the cathode end of the oscillograph tube is therefore grounded (Fig. 3). Maximum deflection sensitivity of the 913 tube is listed by the manufacture as 0.21 mm. per volt. However, at the low accelerating voltage used, only 20 volts is required to deflect the spot to the edge of the screen. For 600-volt operation, 80 volts is required for full-scale deflection. The deflecting plate amplifier is not located on the recorder in this case, but can easily be fitted to it if miniature tubes are employed.

Since no lens is used, it is essential for clear records to adjust the intensity

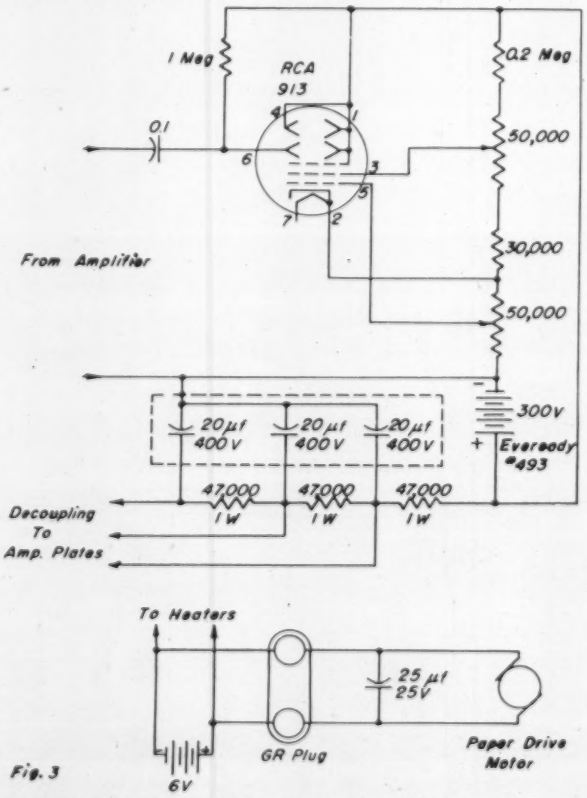

Fig. 3

Fig. 3. Schematic diagram showing method of coupling oscillograph tube to audio amplifier.

*D. L. Supernaw, "The Shadowgraph Recording Method," *Instruments*, Vol. 20, June 1947, pages 532-535.

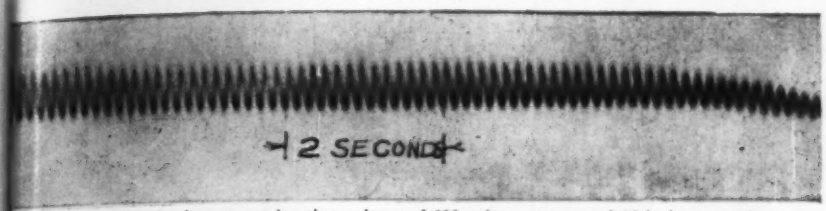

Fig. 4(a). Record taken at accelerating voltage of 300 volts; paper speed 24 inches per minute.

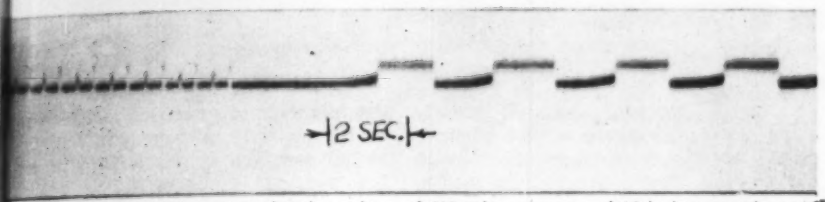

Fig. 4(b). Record taken at accelerating voltage of 600 volts; paper speed 12 inches per minute.

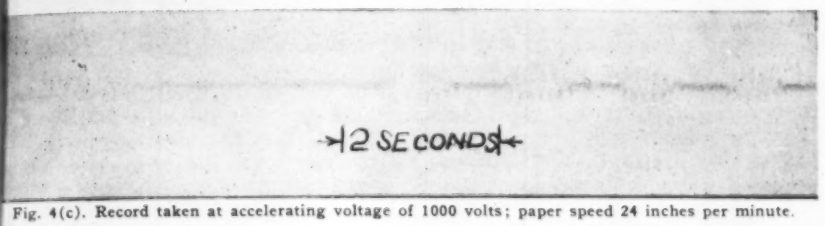

Fig. 4(c). Record taken at accelerating voltage of 1000 volts; paper speed 24 inches per minute.

and size of the spot so as to give the recording paper used the correct exposure. A tape mask forming a 1/64-in.-wide slit is placed over the face of the tube to avoid extra exposure of exposed parts of the record. The slit is perpendicular to the motion of the paper and parallel to the motion of the spot. The width of the trace recorded on the paper is a function of the exposure time for a given spot intensity, and hence is inversely proportional to the speed of motion of the spot, i.e., for high-frequency signals the trace is thinner than for low frequencies. Thus, how the intensity should be adjusted to give a clear record depends on the frequency of the signals recorded. A one-inch focal length lens could be used advantageously to give clear records, but its use was prohibited in this case since it would increase the height of the instrument by four inches.

In its present use the instrument is required to record continuously for at least ten minutes. Its ten-foot supply of paper is therefore drawn past the face of the oscillograph tube at the rate of 12 inches per minute. This limits the resolution of signals to about ten cycles per second or less. In another case the linear speed of the paper could be increased where room is available for a larger paper supply. The highest frequency resolvable would then be limited by the accelerating voltage of the oscillograph tube (spot intensity) and the photographic speed of the recording paper or film. However, the relatively low linear speed of the paper can always be tolerated when it is required only to record the level and duration of signals whose form is irrevelant. It is desirable to use a recording paper of high photographic speed such as Eastman Linagraph Orthochromatic Recording, Type 481 (formerly Type XA). Some typical traces made on this paper are shown in Fig. 4. Note that the width of the trace decreases with increasing accelerating voltage. This is due to the smaller spot size obtainable at higher accelerating voltages.

Acknowledgment. — This work was done under the sponsorship of the United States Navy Department under Contract NOrd 7958. The author takes pleasure in acknowledging the interest and encouragement in this work of Dr. C. H. Tindal of the Ordnance Research Laboratory.

Announcement of Southern California Meter Association's Twenty-second Annual Instrument Exposition, October 4-6

Sixty-four companies and institutions will exhibit at the Southern California Meter Association's twenty-second annual exposition at the Long Beach Municipal Auditorium, October 4, 5 and 6. Exhibit hours, 1 to 10 p.m.

As this issue goes to press, *Instruments* learns that arrangements are under way also for technical sessions.

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PRECISION LABORATORY THERMOMETERS

Their Construction, Production and Uses*

By VALENTINE HIERGESELL, President, H-B Instrument Co., Philadelphia, Pa.

RAT POISON and melted butter—What have they to do with the art of thermometry? Strangely enough they both have had their place and their time in developing a device for the accurate measurement of heat and cold. Joachin d'Alencé (or Dalencé) in 1688 writing in Amsterdam about a method for calibrating a thermometer said this: ". . . put a little butter on the bulb of the thermometer, observe when the butter melts and . . . mark on the panel the height attained by the liquid."

We have come a long way since then, yet, only recently we got around to the use of Thallium Metal, also used extensively for poisoning rodents, in the art of thermometry—a matter I shall refer to later on.

Thermometry owes much to your countryman, Anders Celsius, for his prophetic vision in selection of the fundamental interval upon which he based his Centigrade scale. That he coupled this with the metric system for designation of his degrees seems almost providential. The Centigrade scale is, as you well know, universally accepted in the world's laboratories and is widely used in industry. In at least one country, the Republic of Mexico, the Centigrade scale is the only one that is legally recognized.

Essentially a thermometer is a simple device—a few drops of mercury and a slender glass tube, accurately and delicately fashioned to contain and to seal in the final fluid metal or mercury-thallium amalgam.

To the layman, the glass neither expands nor contracts, while the mercury to his eyes has a wide variation in its volume, when cold and when hot. To the scientist, however, the glass also responds, however minutely, to temperature variations. So that all the manufacturer of glass thermometers has to do is to compensate these four factors of expression and contraction of both glass and mercury so that his calibration of the rise and fall of the mercury column will be accurate to some predetermined tolerance. Accurate, that is, at each degree on the graduated scale. That is ALL he has to do, but I can assure you that it is not so easy as it sounds. For example, The Encyclopedia Britannica, which deals only briefly on such subjects, devotes 14 full pages to the technical discussion of the art in describing only the general principles.

If you take a drop or two of mercury on a watch glass and observe it intently while the temperature of the room is raised several degrees, your eye cannot possibly detect the change in volume of that fluid drop. Now lock that tiny droplet within a small glass bulb having only one point of outlet, a capillary measuring about 0.05 of a millimeter for the expansion of the mercury, and we observe the same principle of the movement of a mercury column, as if the bulb capacity and bore size were increased in ratio to ten or even a thousand times the smallest sizes.

The bulb of a Centigrade mercury-in-glass thermometer has a volume equivalent to about 6000 degrees of the scale. It is obvious, therefore, that if the bulb of such a thermometer suffers a permanent change in volume of 1 in 6000, the readings will be changed by about one degree, and that if the corrections are to remain constant to 0.05 degrees the bulb must suffer no change as large as one part in 100,000.

With the fluid mercury or mercury-thallium amalgam thus entrapped, increase the temperature by one degree and the volume of that droplet expands as it did before. But this time the whole volumetric change is expressed in a measurable portion of the capillary in terms of observed readings, and visible to the naked eye.

By the delicate and scientific combination of the volume of fluid entrapped in the glass, in both bulb and capillary, and by varying the size of the capillary and bulb in combinations running into the millions, to suit your purpose, you have the ability to provide instruments capable of giving you coarse, intermediate or unbelievably delicate readings.

Let us see what are some of the extremes now commonly in use, all of them employing only glass and fluid for their primary elements. At one end of these extremes we provide a thermometer whose whole range of graduations is one single degree of temperature, calibrated with an electric thermometer to record, however, one hundred accurate measurable variations, or perhaps a thousand within that one degree.

The antithesis of this is a thermometer which will, in one instrument, record the full scale of a mercury-in-glass thermometer from minus 30 degrees C. upward to plus 620 degrees C.— a range of 650 degrees C.

Each of these instruments must be calibrated for accurate readings, not merely here or there, but throughout the full scale of graduations. Obviously the permissible tolerances in each individual case are in relation to the scale involved.

As a matter of general rather than technical interest, the sizes in which thermometers are made may be worth mentioning. They have been made as small as 30 millimeters and as long as four meters, of the type with either paper or porcelain scale at the upper section. For diameter they have been made almost as fine as a woolen thread and as large as 50 millimeters.

The glass stem of a thermometer has at its center, a bore or capillary tube usually from about one-tenth to one-hundredth of the entire cross-sectional area of the tube, and this has no significance except for strength of tube, proper magnification of prismatic tubing, etc.

In the manufacture of standard and precision thermometers, great stress is laid upon the bore variation throughout the scale length involved. Various methods can be employed by the maker of good thermometers to reject tubes with undue variations in cross-sectional area of the bore, such as more frequent calibration points and dividing equipment which follows true temperature curves as near as possible.

The mercury-in-glass thermometer attained its highest precision over fifty years ago. The thermometers used and distributed by the International Bureau of Weights and Measures at that time represented a grade and workmanship which it is not worth-while to attempt today. Higher precision than is possible with mercury-in-glass thermometers can be attained easily with electrical thermometers.

The chief kinds of glass used for solid stem type thermometers will be discussed briefly at this point. They are: (a) Lead standard glass, Corning normal glass and borosilicate glass. The principal constituents of the Corning lead stem are lead, silica sand, alumina and alkali fluxes; (b) The Corning normal is a modified high-quality lime glass consisting of silica sand, lime, zinc and alkali fluxes; (c) Borosilicate consists of boric oxide, silica sand, alumina and alkali fluxes. The alkali fluxes in glass act as a fining agent and make for good glass quality.

Corning Glass Works began making thermometer glass in about 1880. The conventional method of manufacture at that time was to draw the glass horizontally, a slow and not altogether satisfactory system. In about 1895 Arthur

*Presented at the Instruments and Measurements Conference, Stockholm, Sweden, May 31-June 7, 1947.

Houghton visited England and there witnessed a method of making tubing vertically. On his return to Corning in 1896 he decided that Corning Glass Works could do a better job of making thermometer glass by the vertical method. With Charles Githler, their Production Superintendent, Houghton developed a hand-operated pulley device for drawing the molten glass upward, and in 1911 they built the thermometer tower, still used by Corning Glass Works for drawing all hand-drawn thermometer tubing.

It was not until 1930 that the automatic machines were perfected to draw thermometer tubing fully automatic. By 1940 all kind of thermometer glass, including clinical tubing, was made by a machine which can operate economically with only a minimum of four to five thousand kilos of yield. Hence, Corning finds it necessary frequently to draw tubing by hand in lesser quantities, for which they are also adapted. In Corning shops begin the first step of thermometer making after the mixing and melting of the ingredients of the glass batch. The ballmaker collects a cherry-red gob of molten glass on the end of his hollow blow iron. He then places the iron horizontally on a support and turns it to form a rough ball. The ballmaker puffs lightly into the small rough ball to form an air space that later develops into the bore. When the ball is ready it is placed into a wooden block or mold to form a smooth, symmetrical shape.

The bore maker is the next artisan to take up the job. He collects a gob of white glass from another tank mouth and smears it over one side of the clear cylinder when both have been cooled sufficiently to avert thermal shocks. Subsequently, the gob is returned to the tank by a coverer to be coated by another gather of clear glass. Then the marverer rolls it on a metal table and kneads it like dough, when, at the same time, he is always gaging the size of the bore in relation to the entire mass of glass. The gaffer chills the upper end of the cylinder with a few blasts from an air hose as the upward draw begins to a height of 60 meters.

Now, from the user's point of view, what can you secure in a glass thermometer for your needs in either laboratory or industrial plants? What are the limitations? In the upper ranges, accurate readings up to 620 degrees C. are common practice. There is, depending upon the fusing point of glass, a theoretical range up to 800 degrees C., if new types of glass suitable for thermometer use are placed at the thermometer manufacturers' disposal. For readings in the range between minus 40 and minus 60 degrees C., we come back to rat poison, a metal known as thallium, long known to scientsts but with other few uses in industry. In 1940 it was tried as an amalgam with mercury for commercial production of precision thermometers, hitherto not usable below about minus 39 degrees C. The results were so satisfactory that, although no heavy demand was at that time in sight, we began to manufacture instruments capable of registering with high precision down to minus 60 degrees C., a big step forward in reliable routine temperature measurements. Almost immediately research laboratories and our government found a great need for this improvement. Sub-zero temperatures in military planes flying at high altitudes depended upon the proper viscosity of hydraulic brake fluids, and their performance could not be jeopardized lest oils would not flow freely at minus 40, 50 or even minus 55 degrees C. So that, to the men whose lives depended in some degree on these instruments, it seemed providential that their manufacture had been started just in time.

You, as users, now have a wide range of temperature measurements available to you in glass thermometers; the ordinary liquid-filled thermometers suitable for use down to about minus 190 degrees C.; the mercury-thallium-filled thermometers for weather station use in cold regions with single-and half-degree graduations down to the more finely divided types for use at specific temperatures only, and the ordinary laboratory ranges such as 110 C., 200 C., 360 C. and others.

The conditions under which you may have to read your thermometers have led the makers to devote much effort to increase the visibility of the fluid column and the graduated scale. At my request, in 1935, Corning Glass Works made up the first batch of yellow-back tubing for so-called chemical thermometers, and with this I made my first public contribution to the wide-spread use of more visible mercury columns throughout America. Even this glass adapted itself to machine drawn tubing, assuring conventional round or elliptical bore shapes not too flat to maintain proper behavior of the mercury column, a factor which is very important in precision thermometer making. Other contributions followed, but I do not wish to bore you with these.

For the sake of simplicity I have spoken only of mercury (except its amalgam with thallium) as the fluid use in glass thermometers. Actually, mercury was a late comer in the art. D'Alencé, writing in 1688, mentions water in his first description of the instrument. But water would freeze and break the glass below zero, so acqua fortes was added to the water in which a little copper was dissolved in order to make it more visible. Colored alcohol is next referred to, a fluid still in use today. Then brandy was tried, and finally mercury. There are many thermometric fluids available today, each having some technical and economic advantage, not appropriate for discussion here.

Those early instruments, as d'Alencé reminds us, were rather cumbersome, approximately one meter in length. But with the introduction of mercury there came a sudden diminution to a length of approximately one-tenth meter for certain types, such as the fever thermometer.

From the simple measurements of temperature by means of the glass thermometer, there naturally developed the use of such instruments to record automatically what the readings had been over a period of time. As a result, the simple device with only two constituent parts (the glass and the fluid) took on a new meaning in the form of numerous modifications and accessories.

Some of the modifications are:

The minimum-registering thermometers in which an index is dragged back in the liquid column when the temperature falls, leaving the index at its lowest point.

The maximum-registering thermometer registers the point equal to where the top of the mercury is pushed.

The thermostat with a fixed control point which has electrodes sealed into the bore of one sort or another, and can be set with a time clock to cook your whole breakfast before you arise in the morning, and many other practical devices too numerous to mention here.

Conclusion

Speaking as a maker of thermometers, a job at which I have spent the past thirty years, I can assure you that the science of thermometry is not at the end of the road. With few exceptions we have found the way to make thermometers to meet conditions as they have been presented by laboratories and industrial users. Sometimes we have created the instrument a little in advance of need.

But to Anders Celsius we must attribute the most far-sighted advance in the art. No simple contribution of one individual in the field has yet equalled his fixing of the fundamental interval at zero and 100 for melting ice and boiling water in combination with the metric scale.

The thermometer has come so intimately into our lives that we scarcely give it a thought. Yet, in many ways, our very lives are now dependent upon it. The premature infant in the hospital incubator has a constant-temperature device as its guardian angel. The fabricator of foodstuffs risks his fortune on the accuracy of his thermometers in his plant procedure. You and your family each day partake of milk that has been safeguarded by pasteurizing, a process dependent upon dependable thermometers. In a thousand ways each day, all over the world, the glass thermometer is serving mankind to protect life and property in varying ways. In the laboratories of the world it has helped make possible the advancement of science, which soon became the commonplace of our daily lives.

May I, in conclusion, go back to that gentleman I first quoted? Writing before 1700 on this art of measuring heat and cold, he said: "Several other types of thermometers might be developed to avoid and correct the disadvantages found in those already invented. That is a challenge to investigators." Speaking for thermometer manufacturers wherever they may be, I invite you to bring us your problems. We accept the challenge!!

Some Application Factors Affecting *the* Regulation *of* pH *in* Industry

By ALLEN L. CHAPLIN, Consulting Engineer

IV. THE ELECTRODES AND SAMPLING SYSTEM

Two general types of electrode assemblies are in common use for industrial applications. These are: (1) the submersible assembly; (2) the outboard flow assembly. The submersible assembly is generally preferred for application to open tanks, and has the advantage that transfer and detection lags are minimal when the electrodes are in direct contact with the tank liquors.

The outboard flow assembly has the outstanding advantage of greater ruggedness and more universal adaptability to industrial use. It can be located in a convenient place, and the electrodes are readily accessible for maintenance. The one disadvantage of this assembly is the transfer lags involved in transferring the test sample from the process.

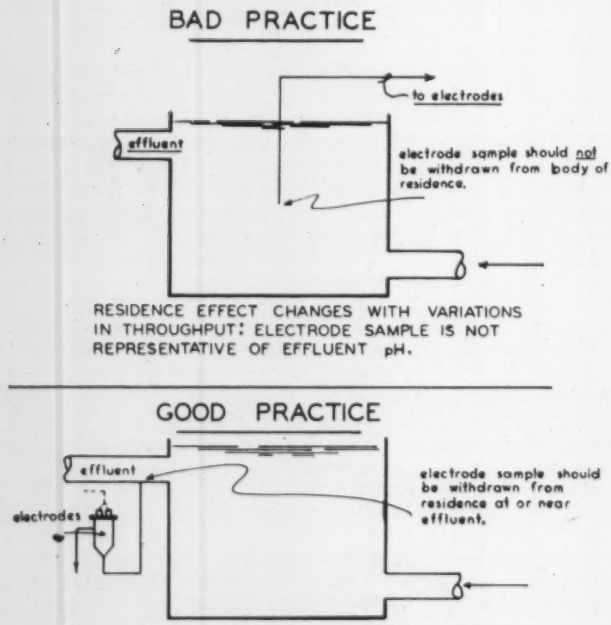
BAD PRACTICE
to electrodes
effluent
electrode sample should not be withdrawn from body of residence.
RESIDENCE EFFECT CHANGES WITH VARIATIONS IN THROUGHPUT: ELECTRODE SAMPLE IS NOT REPRESENTATIVE OF EFFLUENT pH.
GOOD PRACTICE
effluent
electrodes
electrode sample should be withdrawn from residence at or near effluent.

Fig. 43. Electrode sample should be withdrawn from control tank at or near outlet. If better results obtained by sampling body of residence, control tank may be overdesigned.

In general, the assembly should be short-connected to the process as directly as possible. If space limitations or design requirements necessitate remote installation of the assembly, precautions must be taken to limit transfer lags to the minimum requirements.

The point of withdrawal of sample from the process is not important in installations of recorders, but it does have an important bearing on pH control. Generally, it is not good practice to withdraw a sample from the body of a control tank since its residence effect changes with throughput and electrode pH may not be representative of effluent pH (Fig. 43). It should be a standing rule to withdraw electrode sample at or near the tank effluent except for streamline residence which sometimes requires body sampling because of large hold-up in the system. This applies only to streamline residence, and, should better results be obtained from body sampling in conventional control tanks, it may mean that (1) residence is overdesigned; or (2) agitation is inadequate; or (3) an inadequate regulator is applied to the process.

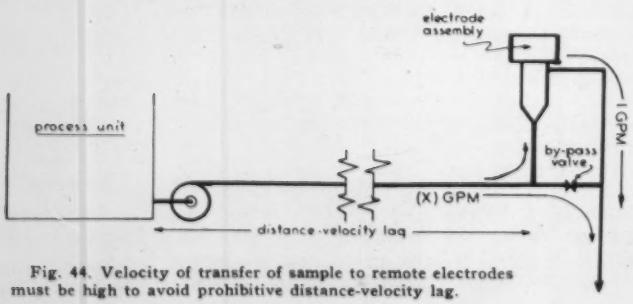

Fig. 44. Velocity of transfer of sample to remote electrodes must be high to avoid prohibitive distance-velocity lag.

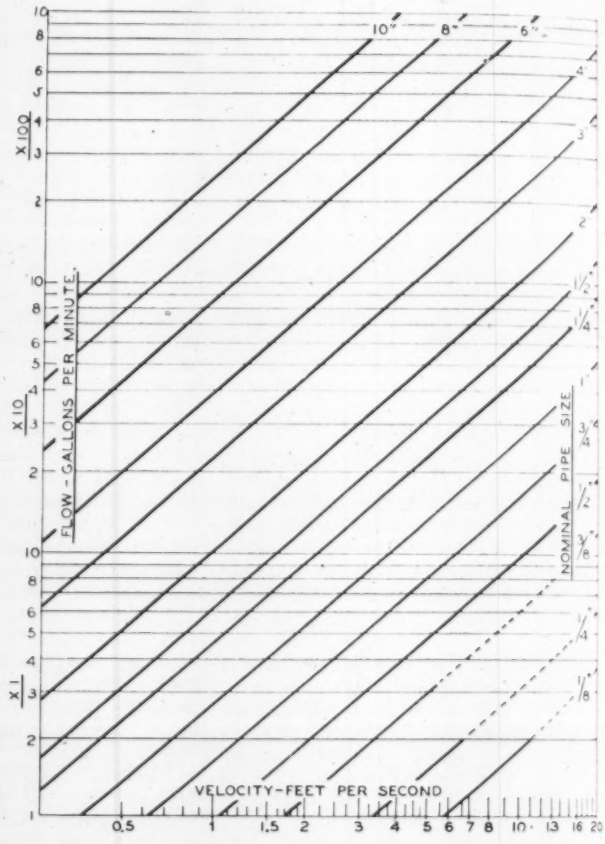

Fig. 45. Conversion chart relating distance velocity and transfer lags in terms of velocity-per-foot or gallons-per-minute flow in pipe lines of various sizes.

Usually, the electrode assembly is limited to a maximum flow-through capacity of 1.0 to 2.0 gpm. and, should the length of transfer line be so great that this volume cannot be transferred in the required detection time, the effective lag may be decreased as shown in Fig. 44. Velocity of transfer is increased and lag reduced by by-passing the major portion of sample around the electrodes and "choking off" the required 1.0 gpm. for the electrodes.

Sample lines usually vary in size and length; and it is desirable to know the required gallonage per minute flow which must obtain to estabish the desired transfer time for any given line size. These data may be taken from the nomograph (Fig. 45) which expresses the transfer velocity per foot length of sample line. This nomograph may also be used to determine the required pump capacity to deliver a sample to the electrodes through a specified line size in a given time and length of connecting piping. For example, if the electrodes *must* be located at a distance of 10 feet from the processing vessel, and if buffer index of the process per-

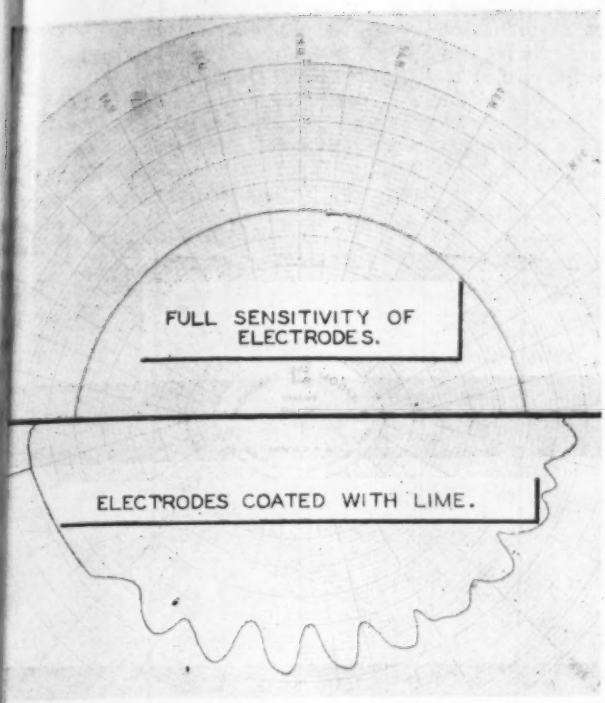

Fig. 46. Relative effect of electrode sensitivity on response of pH recorder. Lower chart represents control record with electrodes coated with lime. Upper chart is representative of control obtained using clean electrodes. Lower chart is not a true record of pH variations in process.

mits a maximum transfer lag of 5.0 seconds (corresponding to 0.5 second per foot of sample line), we find by reference to the chart that flow through a one-inch sample line must be maintained at 5.25 gpm., or more, to satisfy this condition. But the electrode assembly is capable of handling only 1.0 to 2.0 gpm., and it is necessary, therefore, to short-connect a by-pass valve around the assembly as described in connection with Fig. 44. Furthermore, a standard one-inch centrifugal pump may deliver sample at approximately 10 gpm. which means that, under these conditions, the actual sampling lag would approximate 2.5 seconds.

Electrode sampling lines should not be installed without engineering appraisal and without exact design specifications. They should not be installed indiscriminately for the purpose of grouping a number of assemblies in a battery at some remote location. Electrode assemblies should be as short-connected to the process unit as is practical: each foot of connecting piping adds transfer lag which may defeat an otherwise good control installation. It has been a matter of field experience that sample transfer lag should not exceed a maximum of five seconds for processes having a buffer index in excess of 1.0; or a maximum of fifteen seconds for a buffer index of 0.5 or below. When electrodes *must* be remotely located, the sample line and pump must be sized in accordance with Fig. 45 to maintain lags at or below the allowable maximum.

Normally the sample transfer line should not be larger than 1-in. standard pipe size unless larger sizes are required to handle suspensions. In cases where suspensions are involved, it is customary practice to use crosses or tees at every pipe turn to facilitate cleaning the line. It is also recommended practice, in all cases, to connect a water flush line near the electrode assembly for the purpose of flushing out the sample line and assembly during shut-downs; or to facilitate cleaning the electrodes without interruption of the process or controller.

* * *

Occasionally the control engineer encounters applications wherein a foam accumulates in the electrode assembly and builds up to the point where it insulates the electrodes from the test liquor, or restricts the flow of test sample through the assembly. In such cases, it has been found possible to minimize the effect by inserting a defoaming pot in the sample line ahead of the electrode assembly. The defoamer consists of a small chamber located at a slight head above the assembly, and is of sufficient volume to serve as a stilling chamber which permits the foam to collect on the liquid surface and be drained off continuously through an overflow.

Other applications are frequently encountered wherein a precipitate is formed and coats the electrodes, thus rendering them insensitive to pH changes. The resultant control is wild and unstable, and the recorder behaves as indicated by Fig. 46. It has been the writer's experience that electrode coating is a function of equilibrium lag, and it adheres tenaciously when the electrodes are located at a point in the process stream where crystal growth is positive, i.e., the precipitate is forming from solution. If the electrodes are located at a point beyond the range of crystal growth, the coating either does not form at all or adheres rather loosely: It has been possible, in many cases, to avoid coating by relocation of the electrodes.

In some cases it may be possible to meter water into the electrode sample line and prevent electrode incrustation by virtue of the effect of water on reversing the rate of crystal growth. One such condition was encountered by the writer on an acid neutralization job where milk of lime was used to neutralize waste acids. The neutralization reaction formed calcium sulphate which clogged up sample pumps and coated the electrodes with a half-inch thick incrustation within a half-hour's time.

The control tank illustrated in Fig. 47 was below ground level and necessitated pumping the electrode sample. Me-

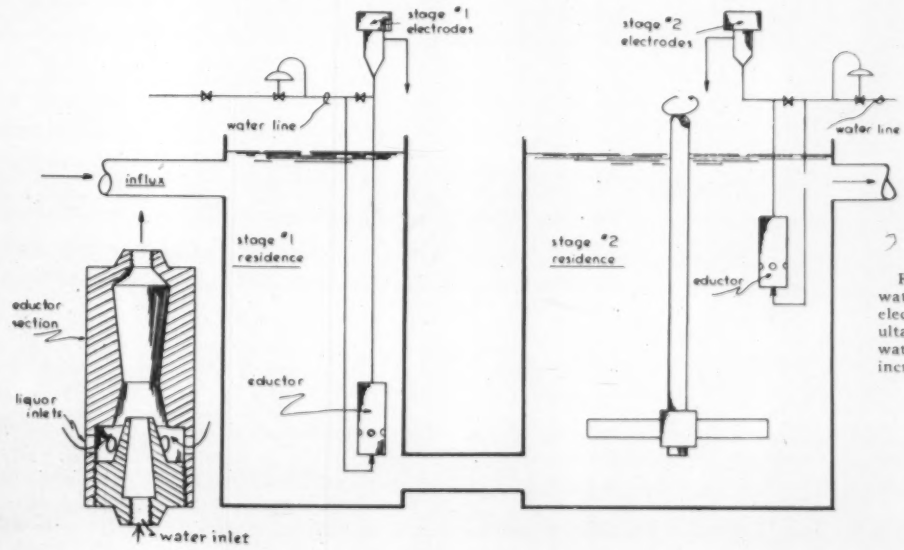

Fig. 47. Application of water eductor to withdraw electrode sample and simultaneously dilute with water to prevent electrode incrustation.

chanical pumps were useless, but a water eductor served satisfactorily the two-fold purpose of pumping the sample and simultaneously diluting it to reverse crystal growth.

The eductor was designed and built with a one-to-one jet ratio, so that fluctuations in water pressure would not alter its pumping ratio. It was submerged 3 feet beneath the liquid surface and was equipped with auxiliary water sprays which flooded the lower outside portion to prevent build-up of incrustations over the intake openings. The assembly was quite successful and operated continuously for two-week intervals without interruption except when the process was shut down for removal of accumulated incrustation throughout the system.

At first thought this may appear to be an unorthodox procedure, but inspection of Fig. 48 will reveal its true

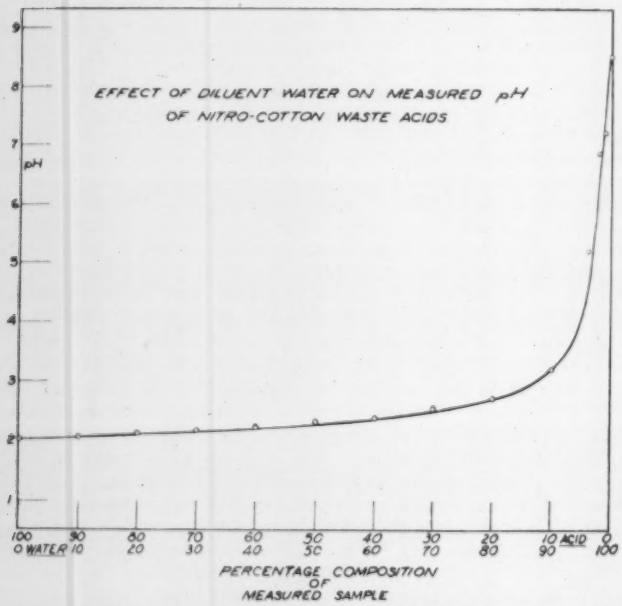

Fig. 48. Strong mineral acids may be diluted with water to minimize electrode fouling without appreciably changing the measured pH.

worthiness. A ratio of only 15 percent water to 85 percent acid was necessary to prevent incrustation, but the eductor delivered a ratio of 50 percent acid to 50 percent diluent water which resulted in only a +0.3 pH change of true pH. This was compensated by adjusting the controller set point 0.3 pH higher than actually desired. This assembly operated in the low acid range of the first stage of a two-stage cascaded residence system and was exposed to all load fluctuations of the wildly varying input stream. Its job was to smooth out the major load swings for the second stage.

The second stage operated at 7.0 pH and was not so seriously affected by incrustation build-up. It was possible to pump the electrode sample continuously for one day without excessive pump maintenance. Nevertheless, a second 1:1 eductor was installed to lift the sample and simultaneously reverse crystal growth. The effect of diluent water at 7.0 pH is much more pronounced though not serious, and, by installing a pressure regulator on the water supply line, it was possible to operate with pH of the effluent regulated to within 0.5 pH of the true value.

A similar condition was encountered by the writer on a job where waste pickle acid from a steel mill was neutralized batchwise in a large mixing sump. The sump was first filled about two-thirds full with waste acid which was blended thoroughly with several hundred pounds of shredded paper pulp. Addition of lime to a controlled pH had the initial effect of converting dissolved iron to the ferric state, after which a heavy sludge formed and became so thick that a submersible electrode assembly could hardly be pulled out of the mass, let alone measure pH. The resultant sludge was filtered, pressed and fired to form an insulation brick.

A special submersible electrode assembly, illustrated in Fig. 49, was built for the job. It was fabricated from extra-heavy 2-inch pipe having an expanded bell welde to th bottom for installation of the electrodes. An outer p tectiv casing, made from 6-inch wrought iron pipe and dri d with several 1-inch holes, provided mechanical protectio to th electrodes. In addition, four water jets were welde to th protective casing in diametric opposition and pointed irectly at the mid-section of the electrodes. During operati , abou 10 gpm. of fresh water sprayed over the electrod to re verse crystal growth and prevent incrustation ild-up Operation was quite satisfactory and no unusual ainte

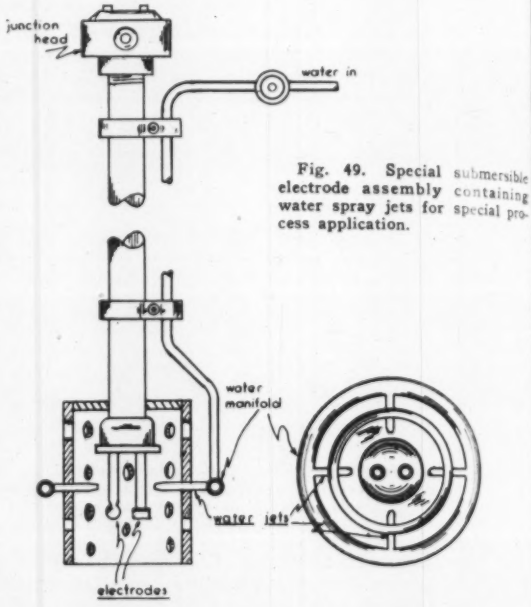

Fig. 49. Special submersible electrode assembly containing water spray jets for special process application.

nance was required of the electrodes over a normal "run" of the process, which usually amounted to five days on an eight-hour schedule. Without the water, the electrodes were entirely useless and became inoperative and coated with a brown tenacious deposit within a few second's time.

The reader is referred to Fig. 50, a reproduction of an actual chart from this process, to understand why it was possible to spray the electrodes continuously with water without serious effect on measured pH. The region of strongest buffering action of the liquor is 7.0 pH and the end point (control point) is 7.5 pH. More than 80 percent of the total

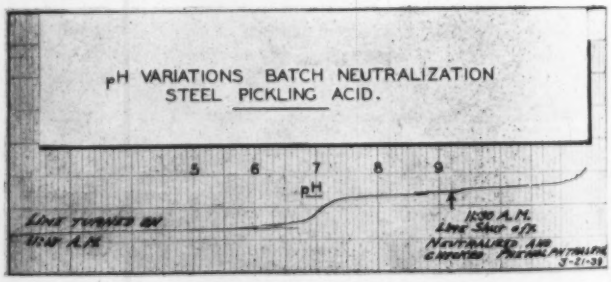

Fig. 50. Record of pH control of steel pickle liquor neutralization process using proportional regulator with manual reset and electrode assembly of Fig. 45. Drift above control point due to occlusion.

lime was required to increase pH from 6.8 pH to 7.2 pH, and, although water could have little effect on such buffering action, it did serve the useful purpose of keeping electrodes clean and operable.

* * *

In some cases, the problem of sampling strongly corrosive liquors in buried or below-floor tanks presents an acute problem requiring costly alloy sampling pumps or special techniques for withdrawing the sample. Water lifts may not be permissable because of an extreme buffer index or because of enhanced corrosion caused by water dilution. In such cases, it has been the writer's experience that expendable air-lifts

Continued on page 838

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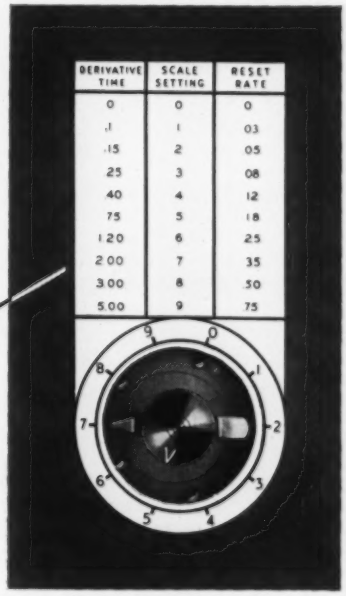

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Electron-optical Shadow Method *for* Plotting *and* Measuring Microscopic Fields

WASHINGTON, D. C.—As the result of a series of electron-microscope experiments at the National Bureau of Standards, Dr. L. L. Marton of the Bureau's electron physics laboratory has developed an electron-optical shadow technique which provides a valuable tool for the quantitative study of electrostatic and magnetic fields of extremely small dimensions. The new method makes use of an electron lens system to produce a shadow image of a fine wire mesh placed in the path of the electron beam. From the distortion in the shadow network caused by deflection of the electrons as they pass through the field under study, accurate values of field strength are computed. Thus it is possible to investigate quantitatively fields that have not been susceptible to other methods of investigation, for example, the fringe fields from the small domains of spontaneous magnetization in ferromagnetic materials.

The new development, based on extensive theoretical analysis, should provide a powerful means for broadening present knowledge concerning space-charge fields, fields produced by contact potentials, patch fields in thermionic emission, charge distribution in a gaseous plasma, waveguide problems, and the basic magnetic properties of metals. Though similar in some respects to the electron-optical Schlieren method* previously developed at the Bureau, the shadow method is much better adapted to precise determinations of field intensity.

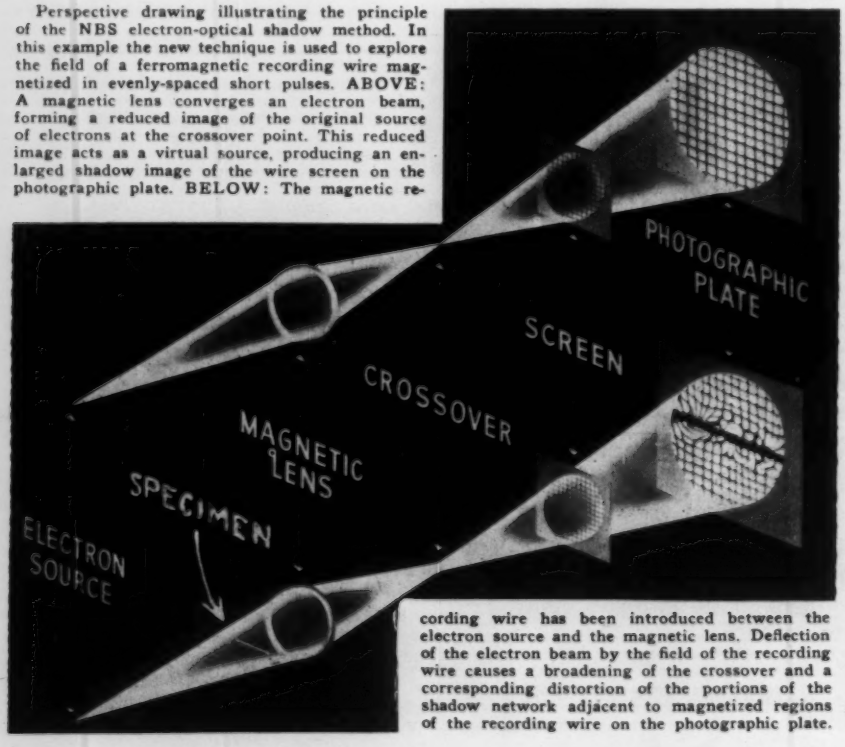
The principle of the shadow method was discovered in the course of a study of a recording wire magnetized in evenly-spaced short pluses by means of a conventional magnetic recording head. In practice, the recording wire—or other object to be studied—is placed between an electron source and a system of electron lenses. The lens system focuses the electron beam to form an image of the wire on a fluorescent screen. By placing a wire mesh of known gage just beyond the back focus of the lens system, a shadow image of the mesh is superposed on the image of the wire. This shadow image is formed by projection from the virtual source provided by the reduced image of the source of electrons. The portions of the shadow network adjacent on the screen to magnetized regions of the recording wire are then found to show considerable distortion.

Formulas derived by S. H. Cachenbruch of the Bureau staff permit the calculation of consistent absolute values of field strength in magnetic or electric fields of various geometrics from experimental measurements of the position of the wire mesh, the displacement and magnification of its shadow image, and the known constants of the apparatus.

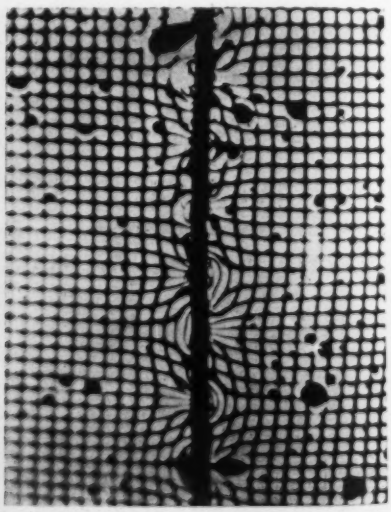
The patterns obtained provide also a qualitative visual representation of minute electrostatic and magnetic fields. Although it is possible to compute field intensity from the intensity distribution of the pattern obtained by

*In the Schlieren method, a magnetic lens forms an image of a source of electrons on a small copper stop which intercepts all direct rays. If in the space between the electron source and the lens there is a variation of the index of refraction for electrons—in other words, a variation in electric or magnetic field intensity—an image of that inhomogeneity will then be produced by means of the same lens in a conjugate plane beyond the stop. Thus a dark-field image of the magnetic or electric field is obtained on a fluorescent screen or on a photographic plate.

Dr. L. L. Marton of the Bureau staff, who designed the special electron microscope, is shown at the control panel.



Perspective drawing illustrating the principle of the NBS electron-optical shadow method. In this example the new technique is used to explore the field of a ferromagnetic recording wire magnetized in evenly-spaced short pulses. ABOVE: A magnetic lens converges an electron beam, forming a reduced image of the original source of electrons at the crossover point. This reduced image acts as a virtual source, producing an enlarged shadow image of the wire screen on the photographic plate. BELOW: The magnetic recording wire has been introduced between the electron source and the magnetic lens. Deflection of the electron beam by the field of the recording wire causes a broadening of the crossover and a corresponding distortion of the portions of the shadow network adjacent to magnetized regions of the recording wire on the photographic plate.



Magnetic field about a ferromagnetic recording wire, magnetized in evenly-spaced short pulses, demonstrated by electron-optical shadow method. Superposed on the image of the recording wire is the electron shadow of a fine wire mesh placed just beyond the back focus of an electron lens. This shadow is distorted by deflection of electrons passing through the field of the wire. From the displacement and reduced magnification of a selected part of the mesh, the absolute value of the magnetic field intensity at a corresponding point in the field can be accurately computed.

the Schlieren method, the shadow method is of far greater utility for quantitative work since the image displacement and magnification can be measured much more accurately than can the intensity distribution across the Schlieren pattern on a photographic plate.

Perhaps the greatest value of the electron-optical shadow method lies in its utility for exploring complex electric and magnetic fields of extremely small dimensions or in which a probe of size greater than the electron would disturb the field under study.

Experiments now under way at the NBS include a study of the behavior of the fringe fields of the ferromagnetic domains; in this work a single crystal of cobalt is being used.

In another application of the shadow method at the Bureau, space-charge fields in several types of apparatus employing electron beams are being investigated. In this connection, use of the method with a pulsed electron source for the stroboscopic study of fields that vary with time is under study.

The Bureau is also applying the principle of the shadow technique to the study of spherical aberration in electron lenses. When a fine wire mesh is placed in the focal region of a lens having spherical aberration, the shadow image of the network is enlarged either centrally or at the periphery, depending on the position of the mesh and the nature of the lens error. The resultant pattern may thus be interpreted to give information of value in correcting the lens.

Magnetic Fluids Find New Instrumentation Uses

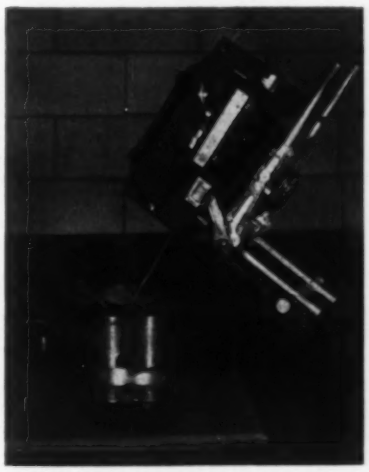
WASHINGTON, D. C.—The magnetic fluid originally used in the electromagnetic fluid clutch* developed at the National Bureau of Standards has several unique features that make possible other important applications of iron-oil mixtures. Further studies of the properties of these mixtures have revealed that magnetic fluids can be employed to good advantage in hydraulic systems and dash pots, and as variable electrical resistors. The basic property on which all these applications depend is that the viscosity of a magnetic fluid is directly related to the strength of the applied magnetic field—the fluid may be changed from a liquid to a nearly solid state and back again at will.

When a magnetic fluid is used in a nonrotating device, the iron particles in the mixture must remain in suspension and not settle out. One way of achieving this is to use a thixotropic fluid. Another way is to maintain a small magnetic field in the mixture during idle periods. In rotating machinery, settling is less important as long as the iron powder can be readily remixed with the fluid. This can be achieved by adding a surface-active ingredient to the iron-oil mixture.

One engineering application proposed in the Bureau's preliminary investigation of new uses for magnetic fluids is the magnetic flush dash pot, in which the rate of motion of the plunger can be readily controlled by magnetically varying the viscosity of the fluid. The rate of response of the magnetic fluid is high enough to provide virtually instantaneous changes in viscosity, thereby making possible a shock absorber with automatic compensation.

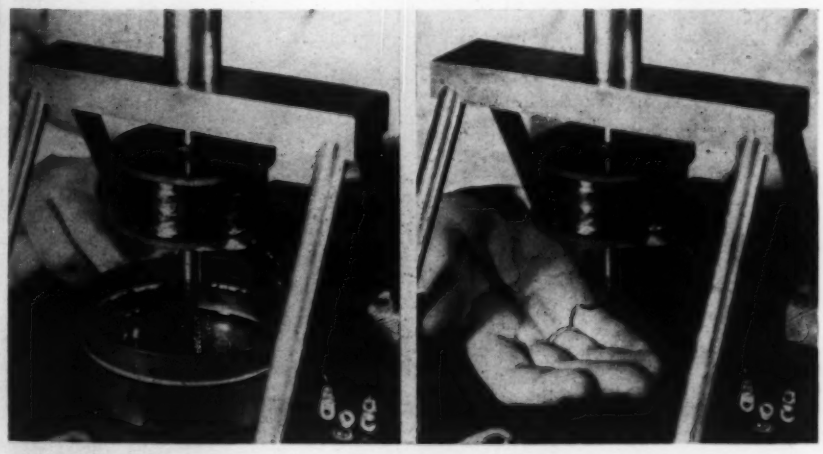
The electromagnetically-controllable fluid offers interesting possibilities for use in hydraulic systems. If a hydraulic system is filled with a magnetic fluid, valving becomes extremely simple: By winding a coil of wire around a fluid-carrying pipe and controlling the amount of current through the coil, the flow of fluid past that point can be closely regulated from full flow to complete cut-off. An obvious advantage of this scheme is that various points in a hydraulic system can be remotely controlled from a central station. Another advantage—of great practical value—is that valve locations can be added or changed easily and without pipe-fitting lost time.

An electrical resistor adapted to remote control can be made by immersing two electrodes in a magnetic fluid. When the fluid is in an unmagnetized condition, the resistance between the two electrodes will be extremely high because of the very loose contact among the conductive iron particles that are randomly distributed in the nonconductive oil. In the presence of a magnetic field, however, the iron particles apparently form chains along the lines of magnetic flux and draw into close physical contact. The flux density will determine the massiveness of the chain and, thus, the conductivity of the mixture. When the system is de-energized, the conductance does not drop back to its former very low level. This property of magnetic fluid resistors is attributed to the coherer effect investigated by Branly, Marconi, and others.



A positioning device, using magnetic fluid, consists only of a ball resting in a cup filled with magnetic fluid and surrounded by an electromagnet. The fluid can be changed from a liquid to a solid state simply by increasing the current through the electromagnet to the proper valve. This type of positioning mechanism might be used to good advantage in such devices as height gages, supports for optical equipment, etc.

Instruments, Vol. 21, Aug. 1948, pages 756, 758, 760, 761, 762, 764. (Full description, with 14 illustrations.)



Laboratory model of a magnetic valve to control the flow of magnetic fluid in a hydraulic system. At left, zero current in the coil, resulting in full flow; at right, the current is great enough to completely stop the flow.

NBS Gets G-E Precision Power-supply Equipment

SCHENECTADY, N. Y.—The National Bureau of Standards has received what is believed to be the most accurate wide-range electric power controller yet to be made by man, according to engineers of the General Electric Company.

Electric power fed through the new wide-range power supply equipment is kept from varying more than 0.005 per cent, the G-E designers said. The in-

strument will be used by the Bureau of Standards in making electrical measurements requiring a virtually unwavering power supply. Since voltage on an ordinary power supply may vary by as much as ten per cent, it consequently cannot be used in delicate measurements, the engineers explained.

The new equipment features a continuously-variable voltage output from 500 to 50,000 volts with a minimum current output of one milliampere. The high voltage is attained through the use of a radio frequency oscillator, power amplifier, r-f. transformer, and a ladder-type voltage tripler circuit. Use of the r-f. source, about 40 kc., makes possible reduction of the output ripple to a low value by simple filtering means. This minimizes the equipment's weight (350 lb.) and size (84 x 23 x 20 in.).

Ground "Flight-testing" *of* Flight Instruments

DAYTON, Ohio.—No pilot, military or civilian, wants an instrument that is guaranteed to get him "pretty close" to where he is going "most of the time." He has to have one that tells him *exactly* where he is going, and tells him correctly *all* of the time.

At Air Matériel Command headquarters at Wright Field, a recently modified Link C-8 Instrument Trainer is acting as the guinea pig to test new instruments under operating conditions — right on the ground. In addition to standard flight and engine controls, this trainer includes an automatic pilot, a revised altimeter system, provisions for recorder take-offs, and additional instrument mountings.

One of the most important pieces of equipment is a large console holding eight strip-chart recorders with their controls. One or all of these recorders can be hooked up at will, through take-offs, to altitude, power, air speed, or other flight variables. Tolerances can be preset on each recorder, and the trace of the pen on the moving chart records all variations throughout the course of a problem. These records can be studied later for significant detail.

When a new type of instrument turns up, one is installed in the Link Trainer, a dupicate in the instructor's console. Then pilots are called in from nearby operational squadrons. Each is briefed on the new instrument and told, "Fly a standard problem, making use of this instrument, and see how close you can stay to these preset criteria of speed, altitude, etc."

Fifty or a hundred pilots repeat this performance, thus providing an average level of proficiency against which to judge the performance of the instrument. If the results are consistently good, so is the instrument. If they are uniformly plus (or uniformly minus) some technical cause must be ferreted out. If they are irregular or unreliable, then the instrument needs improvement.

For a double check, the actual pilot is replaced by switching on the automatic pilot. Now the voltages which normally activate the instrument itself are fed directly to the autopilot, which obeys them just as the human pilot obeys the readings on the face of the real instrument — but the autopilot is quicker, and more accurate. If the performance of the instrument system is correct, the results will be perfect. If not, the the wavy line on the graph will provide an inexorable check.

Harry Diamond Ordnance Laboratory Dedicated

WASHINGTON, D. C. — Dedication ceremonies for the Harry Diamond Ordnance Laboratory were held on May 6, 1949, at the National Bureau of Standards in the presence of representatives of Government and industry. Mr. Diamond's death on June 21, 1948 was a great loss to the National Bureau of Standards and to research. One of the Government's most brilliant scientists, he was organizer and first chief of the Bureau's Ordnance Development Division during the war, and later of the Electronics Division, which at the present time includes the ordnance work. Mr. Diamond pioneered in the development of radio navigational aids for aircraft. His basic Instrument Landing System (ILS) for blind landing has been adopted in many forms throughout the world. Another development of world-wide importance in which he had a major role is the radiosonde, which

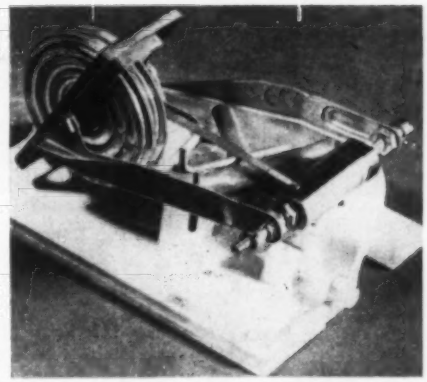
*Instru*Merriment

automatically collects weather information from the upper atmosphere. One of the inventors of the radio proximity fuze, Mr. Diamond also made valuable contributions to visual radio beacons, aircraft engine ignition shielding, aircraft antenna design, automatic weather stations, radio wind-measuring systems, the electronic bomb director, and guided missiles.

Constant-altitude Control *for* Weather Balloons

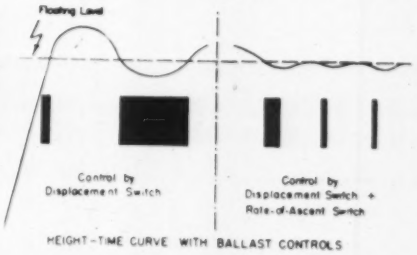
VANCOUVER, B. C.—New controls which hold meteorological balloons at remarkably constant altitude levels were described here by James R. Smith, New York University College of Engineering, at a two-day joint session of the American Association for the Advancement of Science and the American Meteorological Society.

Automatic controllers have been developed to keep plastic instrument-carrying balloons at one or more selected constant pressure altitudes. In three different studies these balloons have provided unique tests, both quantative and qualitative, for meteorological theory. As a vehicle, the balloons have carried loads to 100,000 feet, have been held within 2 millibars of a constant pressure and have remained aloft in excess of 75 hours.



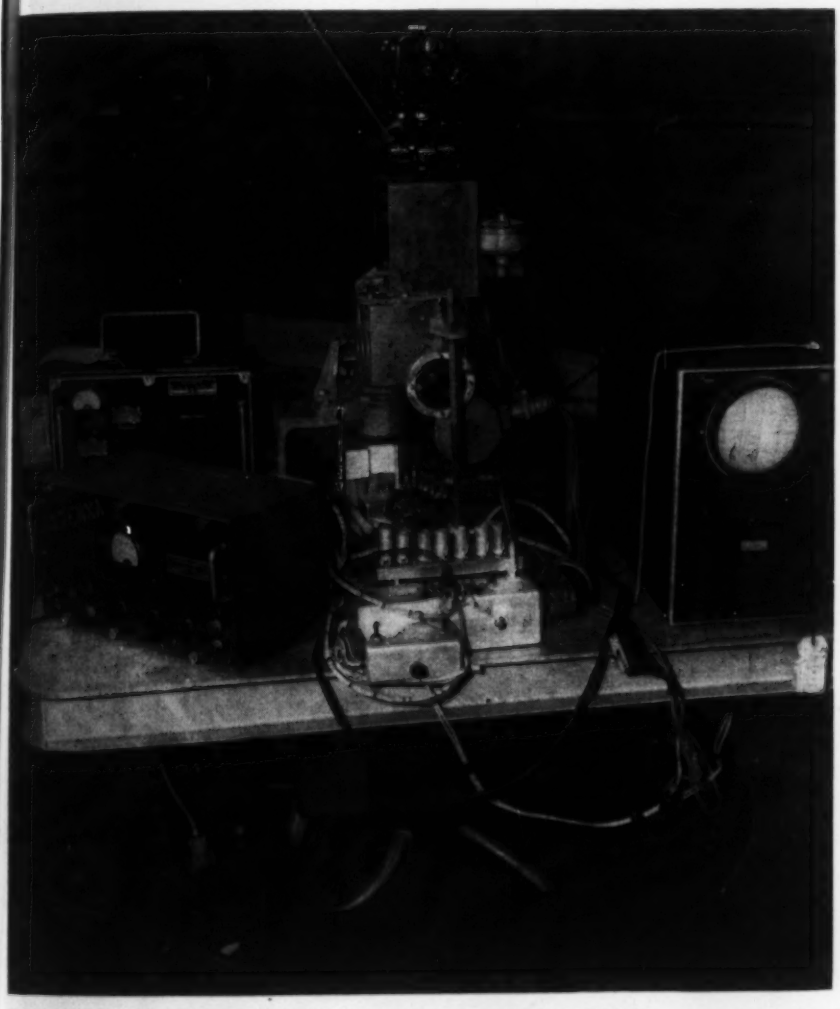
The displacement switch, an aneroid pressure capsule, acts at predetermined pressure-altitudes.

The new balloon controls are the result of work undertaken in November, 1946 by the Research Division of the College of Engineering of New York



HEIGHT-TIME CURVE WITH BALLAST CONTROLS

University under contract with Watson Laboratories of the Air Force Air Matériel Command. Objective was to develop and test controlled-altitude balloons capable of maintaining constant pressure-altitude for long periods of time. The altitude variation desired was to be no more than 500 meters, and the floating altitude was to be selected in advance of each flight.



GROUND-TESTING TURRET'S FIRE-CONTROL EQUIPMENT. Scorsby unit designed and built by The Glenn L. Martin Co. simulates motions of an aircraft in flight to test various components of an advanced fire-control system. The three major components of a fire-control system include (1) a radar sighting system which continuously indicates the direction and distance of the target; (2) a computing mechanism which instantly calculates, from radar data, where to point the turret's guns so that the moving target will be hit; (3) a turret capable of rotating in a full circle with its guns able to elevate 90 degrees, with sufficient hydraulic or electric power to move the guns rapidly and precisely under command of the sighting and computing components.

NBS Method *for* Microsectioning

WASHINGTON, D. C.—A new method in ultra-microtomy, developed by S. B. Newman, Emil Borysko, and Max Swerdlow of the National Bureau of Standards, now provides an inexpensive, practical means of preparing very thin sections of biological tissue for study with either the light or electron microscope. In the new procedure, *n*-butyl methacrylate is polymerized around the speciment to produce an optically clear embedding medium having highly desirable cutting properties. A smooth, continuous advance of the specimen toward the knife of a slightly modified conventional microtome is then obtained from the thermal expansion of a metal specimen holder. Thus, sections of tissue having uniform thickness of fractions of a micron over a large area and undistorted structure may be cut one at a time.

To investigators who use the electron microscope in such fields as cancer research and the study of virus diseases, the need of an efficient method of producing uniform thin sections of tissue has been apparent for several years. Indeed, the application of the electron microscope to many biological problems has been seriously hampered by the lack of such a method. Because of the very slight penetrating power of the electron beam in commercial instruments and the great relative depth of field involved, specimen structure is difficult to interpret when sections are over a fraction of a micron in thickness. Yet the techniques that have been available for preparing thin sections are quite elaborate and difficult, re-

quiring expensive equipment and producing few usable sections.

Of the various solutions to this problem that have been suggested, each has apparently been applicable only to a selected group of materials.

The NBS therefore undertook to develop a rapid, efficient sectioning procedure which could be carried out in routine fashion by an operator without a great deal of special training. The resulting method, which goes far in accomplishing this objective, should be of decided advantage in those fields of biology, medicine, agriculture, and industrial technology that are concerned with the microstructure of plant and animal material.

The detection of structural details in some of the biological tissues sectioned at the Bureau was greatly improved by metallic shadow-casting in the manner of Williams and Wyckoff.

TECHNICAL SOCIETIES

Texas A & M's Short Course

The Agricultural and Mechanical College of Texas will offer the fourth short course on "Instrumentation for the Process Industries," on October 12, 13 and 14. The course will be conducted as a seminar with lectures and discussions on the subject of automatic control. Cooperating will be many industrial concerns. Instrument manufacturers also will show educational exhibits and provide lecturers. The lectures will cover the subjects of measurement and control of temperature, pressure and liquid level, time control, and other allied subjects. The relationship between practice and basic control theory will be stressed.

Anyone living either in or outside Texas is eligible to take this course on payment of the $5.00 registration fee; pre-registration by mail is encouraged. Rooming accommodations and meals will be available on the campus at the college dormitories and mess hall at a reasonable price. A banquet and entertainment are also planned.

Further information my be obtained by writing to Professor P. G. Murdoch, Chemical Engineering Dep't, Texas A & M College, College Station, Texas.

SCMA

The October meeting of the Southern California Meter Association will be held on Thursday evening, October 20th at the Rio Hondo Country Club, Downey, Calif. Dinner at 6:30, meeting at 8:00.

Hydraulics Conference

The Fifth Annual meeting of the National Conference on Industrial Hydraulics will be held October 26-27, at the Sheraton Hotel in Chicago. There will be morning, luncheon and afternoon sessions each day—a total of six. For further information, write to James W. Armsey, Illinois Institute of Technology, Chicago 16, Illinois.

Society for Applied Spectroscopy

The October meeting of the Society for Applied Spectroscopy will be held on Tuesday, October 4, at 8 p.m., at the Socony-Vacuum Training Center, 63 Park Row, New York, N. Y. Professor Ralph H. Muller, New York University, will speak on "Instrumental Methods of Analysis."

—RODGER W. LOOFBOUROW

Society for Experimental Stress Analysis

The Annual Meeting of the Society for Experimental Stress Analysis will be held at Hotel New Yorker, New York, N. Y., on November 30th and December 1st and 2nd.

Inquiries should be addressed to the Society for Experimental Stress Analysis, P.O. Box 168, Cambridge 39, Massachusetts.

American Society for Quality Control

An all-day conference on *The Methods and Techniques of Quality Control and Their Application to Industrial Processes* will be held September 17, 1949, from 10:00 a.m. to 3:15 p.m. on the main campus of Rutgers University, New Brunswick, N. J. There will be no charge for the conference. Luncheon, $2.00.

Program: 10:00 a.m.-12:15 p.m., Panel Discussions: (a) Fundamental Techniques of Quality Control; (b) Case Histories from Industry. 1:00 p.m., Luncheon. 2:00 p.m., Address by Gen. Donald Armstrong, Pres., U. S. Pipe and Steel Co.

—SAMUEL P. OWEN

American Society of Mechanical Engineers

The Fall meeting of the ASME will be held at the Hotel Lawrence, Erie, Penna., Sept. 27-30. The Industrial Instruments and Regulators Division will hold a session on Thursday the 29th, 9 a.m., at which Professors Gordon S. Brown and Donald P. Campbell of M.I.T. will present a paper on "Instrument Engineering—Its Growth and Promise in Process Control Problems."

Course in Nuclear Energy

The Graduate Division of New York University College of Engineering will institute a new course called "Nuclear Energy Engineering" during the 1949-1950 academic year beginning in September. Among the subjects: control and operation of a pile, design and construction of nuclear reactors, power production from nuclear reactors, isotope separation and enrichment, thermal diffusion, gaseous diffusion, concentration by electromagnetic methods, instrumentation, and applications of nuclear engineering.

Nucleonics Symposium

Electronic instrumentation in nuclear and medicine will be the subject of a three- conference to be held at the Hotel Comm re in New York on October 31, November nd 2. This is the second annual conference this subject sponsored jointly by IRE and A E.

On the evening of November 1, there will be a round-table discussion on "Evaluation Radiation Hazards" and Dr. Karl T. Compton will deliver an address.

—JEROME D. NTZ

National Electronics Conference

The 1949 National Electronics Conference will be held Monday, Tuesday, and Wednesday, September 26, 27, and 28 in the Edgewater Beach Hotel in Chicago. There will be a total of eighteen sessions, including two on "Instrumentation," one on "Measurements" and—significantly—one on the powerful rivals of electronic tubes, namely "Magnetic Amplifiers."

The three luncheon meetings will be addressed by eminent speakers.

For further information, write to James W. Armsey, Illinois Institute of Technology, Chicago 16, Illinois.

Diffraction Conference

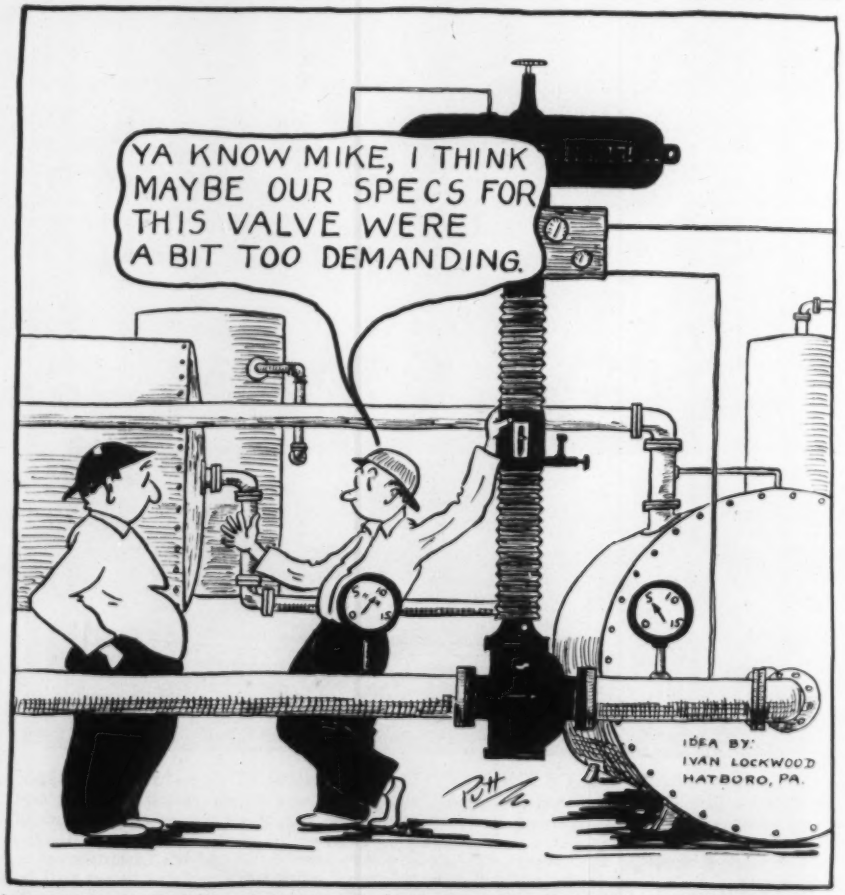
The Seventh Annual Pittsburgh Diffraction Conference will be held on November 7 and 8, at Mellon Institute of Industrial Research, Pittsburgh, Penna. Special sessions are planned for technical papers concerning: metal structures, surface films on metals, instrumentation techniques and methods, and general diffraction.

General Chairman of the Conference is Dr. E. E. Stickley, Pittsburgh Plate Glass Co., Creighton, Pa. Chairman of the Program Committee is Mr. R. K. Scott, Hall Laboratories, Inc., Box 1346 Pittsburgh 30, Pa.

—C. W. CLINE

WHEN A FELLER NEEDS CONTROL

By Phil Putnam



Instruments pays $5.00 for each idea used. Sender's name and company affiliation will be acknowledged in the cartoon unless we are specifically requested not to do so. Address Cartoon Dep't, *Instruments*, 921 Ridge Ave., Pittsburgh 12, Pa.

process control with TRANSAIRE*
Temperature Transmitter with Speed-Act

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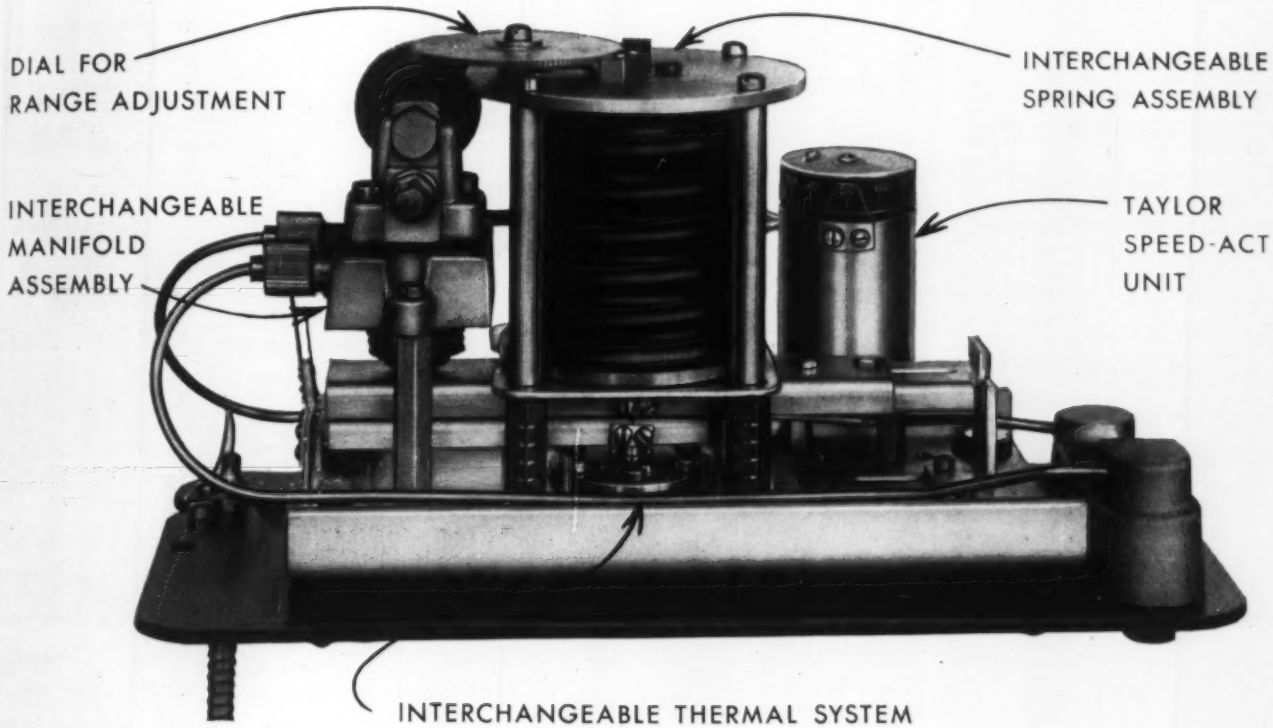
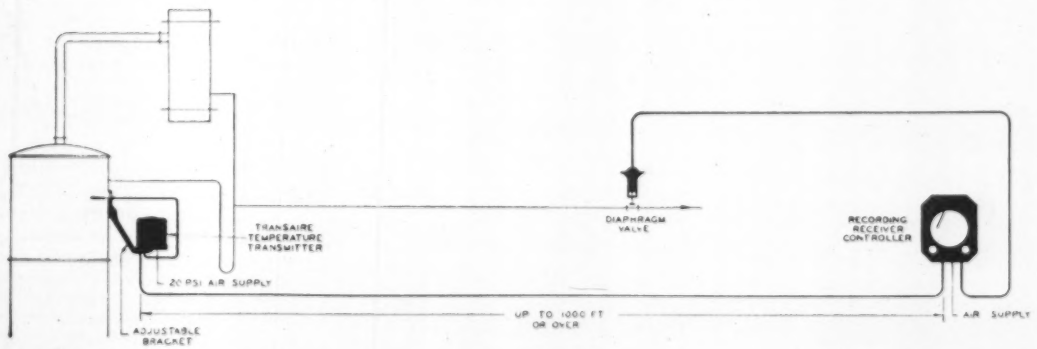




QUICK PICTURE OF DYNAMIC ACCURACY

1. Ambient temperature compensation.
2. Barometric pressure compensation.
3. Speed-Act—a derivative action in the measuring system.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

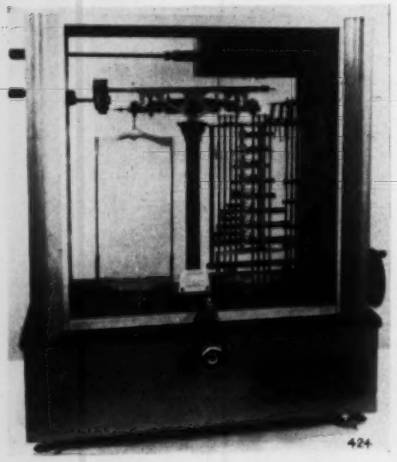
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control — in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 863

Analytical Balance

New "Speedigram" analytical balance permits untrained personnel to weigh objects in less than two minutes; is recommended for volume procedures in production laboratories. It reads directly up to 100 grams without weights.



An extra 100-g. weight is supplied to make 200-g. capacity available. Sensitivity is 0.05 mg. at full load. Numerals appearing through plate over dials indicate weights which will be deposited on pan. Deposition is automatic when beam is released. Readings are made across dial so that no sums need be computed, thus eliminating a source of error. "Speedigram" has no complicated parts and its working parts are in ful view.—*Voland & Sons, Inc., New Rochelle, N. Y.*

Mention No. 901 when filling out card.

Saturable-core Reactors

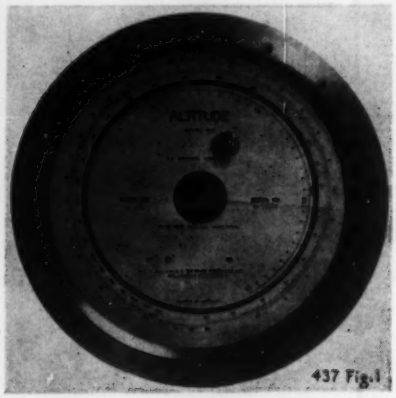
New saturable-core reactors are announced in two types: (1) D-c. control circuit, which operates through d-c. coil: standard reactors designed for about 50 to 150 ma. maximum current and a d-c. resistance of about 2000 to 4000 ohms (5 to 90 watts), designed to work from plate circuit of an electron-tube control. User should specify maximum d-c. coil resistance, maximum direct current

available and, if possible, range of d-c. swing available. (2) A-c. power circuit which operates through a-c. coils: rated by four characteristics: a) Maximum current-carrying capacity of coils; b) Maximum voltage and rated frequency which may be applied across coils; c) Minimum impedance available with reactor saturated (maximum d-c. power input); d) Maximum impedance available with reactor completely unsaturated (minimum d-c. power input.) In addition to standard units, reactors for special applications can be supplied.—*Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.*

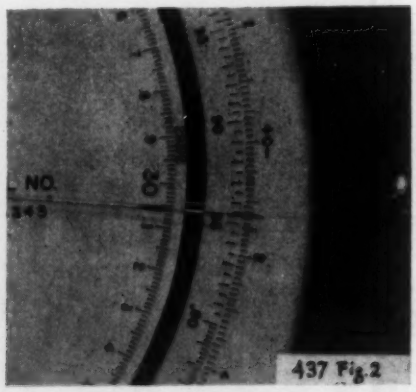
Mention No. 902 when filling out card.

Aneroid Altitude Standard

New high-precision aneroid indicator is designed to improve procedure for calibrating and testing aircraft alti-



meters. Its range is minus 1000 to 30,000 feet altitude with 10-foot graduations in low altitude range. Although dial is 8½ inches in diameter, scale is 45 inches long. Sensitivity and accuracy

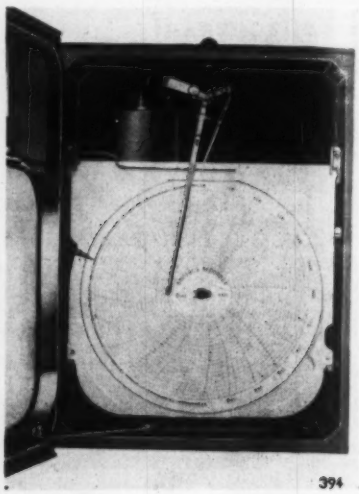


are respectively 1/100 and 1/10 of one percent and instrument is temperature compensated.—*Wallace & Tiernan Products, Inc., 1 Main Street, Belleville 9, N. J.*

Mention No. 903 when filling out card.

Absolute Pressure Recorders and Controllers

New "Series 500" mechanical-type recording absolute pressure gage is said to be based on an entirely new principle, involving a pressure-sealed lever arm

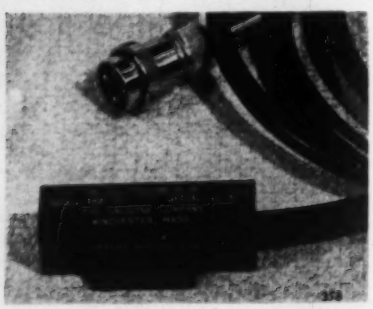


so constructed that it is frictionless, entirely free from lost motion, and free of turning moments due to changes in differential pressure across it. This design makes possible the recording of extremely low absolute pressure ranges: regular ranges from 0 to 20 mm. mercury up; specials as low as 0 to 6 mm. Instrument is rugged for ordinary plant conditions; is offered as a recorder, as an automatic controller, and for remote measurement and automatic control of absolute pressure.—*The Bristol Company, Waterbury 91, Conn.*

Mention No. 904 when filling out card.

Accelerometer Pick-up

New "Model 18 Accelerometer" is said to allow direct operation of voltage- and current-sensitive indicators and recorders to "higher frequency ranges than before possible without complicated amplifying equipment." Standard units weigh 2 oz.; special designs, uncased, weigh only 5 grams. Pick-ups having natural frequencies from 80 to 450 c.p.s. have a corresponding range of



sensitivities from 15 to 0.21 volts per G and acceleration ranges from 1 to 70 G. Natural frequencies as high as 1700 c.p.s. are obtainable. Units are d-c. operated, and can furnish as much as 400 microamperes into 1000 ohms impedance or 20 volts into 1 megohm at full range output without amplification. —*The Calidyne Co., 751 Main Street, Winchester, Mass.*

Mention No. 905 when filling out card.

Multi-point Liquid-level Indicating System

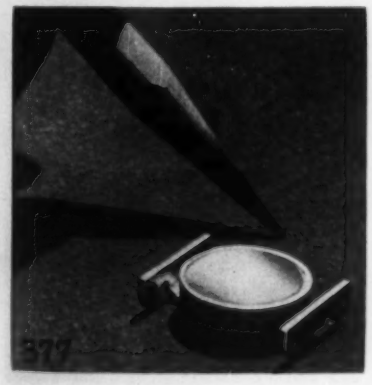
New "Varec System" of remote-indicating liquid-level gaging consists of a number of transmitters and one central-station receiver. Transmitters are available in four designs to meet high- or low-pressure requirements. All are ex-

plosion-proof; two have electrical compartment separated from tank compartment by a solid wall, through which tape-sheave rotation is transmitted by magnetic coupling. Receivers have two dials, calibrated respectively in feet (0-54) and inches (0-12) with ⅛-in. graduations. System is designed for use on 110-115-v. 50-60-cy.; has automatic compensation for supply-voltage variations between 85 and 130; consumes about 100 watts; does not require recalibration in event of power failure. —*Vapor Recovery Systems Co., P.O. Box 231, Compton, Calif.*

Mention No. 906 when filling out card.

Thermostat

New "Type M" compact quick-make and -break thermostat for close temperature control of appliances and industrial apparatus employs a bi-metal thermal element of disk construction. Close temperature control results from electrical independence of bi-metal element. Units are available with a variety of terminal arrangements; operate on relatively small differentials. Maximum operating temperature 600 F. Temperatures as low as minus 60 C. do not impair normal operation. Two styles available: standard closure for normal

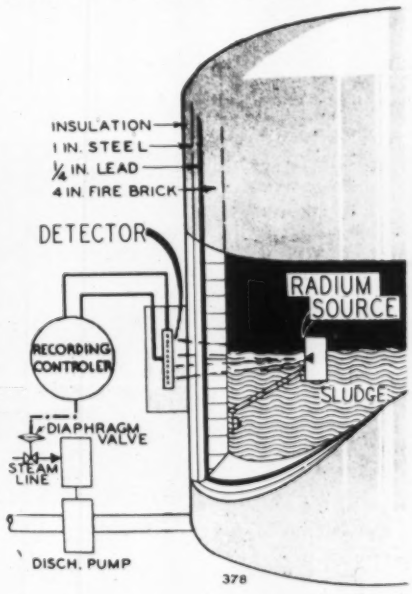


operation; hermetically sealed for special applications; both precalibrated at factory under simulated operating conditions.—*Stevens Mfg. Co., Inc., Mansfield, Ohio.*

Mention No. 907 when filling out card.

Liquid-level Measuring and Control System

New models of "Gagetron" utilize same principle as original model illustrated and described in detail in our Oc-



tober 1947 issue, page 930; but are suitable for a wider range of industrial process applications including high pressures, high temperatures, corrosive conditions, viscous materials, various catalysts such as bead and powder, interface control, etc.—*Instruments, Inc., Wright Bldg., Tulsa, Okla.*

Mention No. 908 when filling out card.

Air Velocity Meter

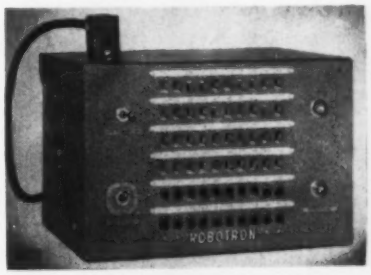
New "Precision Air Meter" has two ranges for measuring air velocities: 0 to 400 and 400 to 6000 fpm.; will meas-

ure air velocities as low as 5 fpm.; is suitable for air conditioning systems, process control, meteorology, etc. Operation combines hot-wire and thermopile principles; eliminates errors due to air temperature variations. Output is suitable for remote indication and operating a standard strip- or circular-chart electrical recording instrument. Illustration shows complete instrument with a tee-section pick-up probe. Indicator is housed in cast-aluminum case with provisions for carrying probe and extension cable; operates from 110-volts a.c.; comes complete with voltage-regulated power supply.—*Hastings Instrument Co., Inc., Box 1275, Hampton, Virginia.*

Mention No. 909 when filling out card.

Hydraulic Press Controller

New "Model No. 140-X Robotron" control unit, designed to perform automatic bumping (breathing) operations on hydraulic presses, can be set to give from 1 to 40 bumps during any one cycle of operation as well as to control over-all cure time. It is wired for use

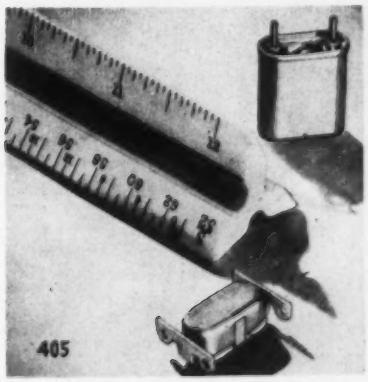


with limit switches to regulate extent of press opening during bumping operations, to close press after a predetermined time, and to hold press closed until next bump. It provides a range of 21 different cure times for each setting of time range switch. Bumps can be timed to be either alternating or consecutive. Push buttons provide instant control of press operations. Once predetermined cure time and bumping arrangements are set, press will continue through cycle without additional attention.—*Emmett Machine & Mfg., Inc., 2249-52 Fourteenth St., S.W., Akron 14, Ohio.*

Mention No. 910 when filling out card.

Thermostat

New "Type C" positive-operating thermostat for control of low-wattage circuits in communications and electronic equipment, apparatus and appliances, can be used alone or in conjunction with disk type thermostats. It features an electrically independent bi-metal strip thermal element said to eliminate artificial cycling or "jitters," so that thermostat responds only to temperature changes. New units are available in a wide variety of terminal arrangements and in many operating ranges up to a maximum of 600 F. Two



basic styles: standard (semi-sealed); hermetically sealed in a metal enclosure. Latter type (pictured at top) is also supplied as an alarm thermostat: a double unit set to open at both a minimum and a maximum temperature.—*Stevens Mfg. Co., Inc., Mansfield, Ohio.*

Mention No. 911 when filling out card.

Low-range Testing Machine

New "Model PTE" universal testing machine uses hydraulic and pneumatic load cells as load-sensitive elements in

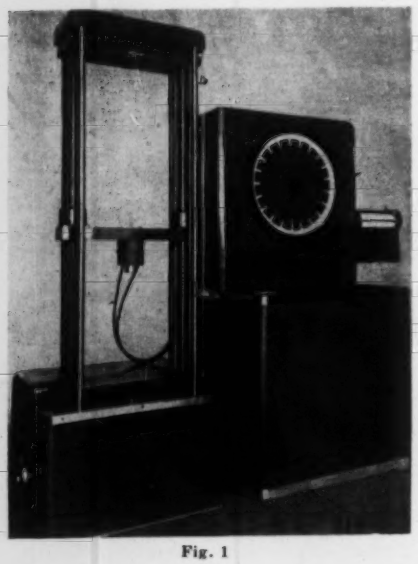


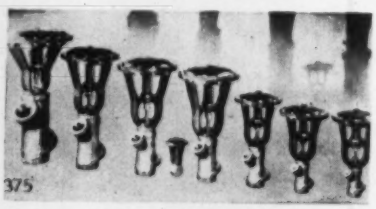
Fig. 1

weighing system, both operating a Tate-Emery indicator. Four standard load ranges are provided by hydraulic cell: 5000-lb., 1000-lb., 200-lb. and 50-lb. (Additional 10-lb. and 2-lb. ranges provided when specified, by means of an air cell.) Tension space may be 3.37 to 51.44 in. and compression space 0 to 48 in. Clearance between vertical screws is 18.25 in. Indicator is housed in a separate cabinet of new design, features including (1) ample space for special accessories for control and indication, (2) accessibility to mechanism through easily removable rear panels, and (3) indirectly-lighted 66-in.-scale indicator dial. Load ranges are shifted instantly by solenoid-operated air valves controlled by a knob on indicator control panel. Loading speeds are held constant by electronic controls in a 400:1 range of 0.05 to 20 in. per minute. Accuracy of load indications is within 0.5 percent of reading, or one scale division, for upper three ranges and within 0.75 percent of reading, or 1.5 scale divisions, for lower three ranges. A recorder may be used with new machine; it will plot stress-strain curves with 10-in. ordinate for one-half and full capacity of any range. Machine is designed for automatic reversal and cycling of loads; may be used with recorder to plot hysteresis curves automatically.—*Testing Equipment Department, The Baldwin Locomotive Works, Philadelphia* 42, *Pa.*

Mention No. 912 when filling out card.

Low-pressure Diaphragm-motor Valves

New complete line of diaphragm-actuated "D-113 Merit" valves for low pressure service are available in sizes



from ¼-in. to 3-in. and for maximum pressures of either 300 or 500 psi. They can be factory-assembled or readily changed in the field for normally-open, normally-closed or for three-way operation. Exhaust side of three-way valves is one pipe size larger than nominal. Permanent disk and stem assembly as well as seat rings are interchangeable among assembly types.—*Emmett Machine & Mfg. Co., Inc.,* 2249-52 *Fourteenth St., S.W., Akron* 14, *Ohio.*

Mention No. 913 when filling out card.

Colorimetric Comparator

New Colorimetric Comparator measures pH by use of non-fading color standards brought into position by rotating a disk. For sharp definition, sample is viewed through a 26-mm. depth and a prism brings sample and standards into juxtaposition. Standards are available throughout range of 0 to 13.6 pH; are also availble for chlorine residual determination. — *Instrument Dep't., Wallace & Tiernan,* 1 *Main St., Beleville, N.J.*

Mention No. 914 when filling out card.

Reversible-polarity Power Supply

New "Model 203" 0 to 30-kv. reversible-polarity d-c. power supply makes 300 microamperes available at 30 kv. It supplements fixed-polarity "Models 201" and "202". By changing two leads, high voltage can be made either positive or negative with respect to ground. Output is Variac-controlled; a kilovoltmeter on control panel indicates output voltage, is at ground potential; a reversing switch is used to reverse kvm. polarity. Input: 117 volts, 50/60 cycles, 225 va. maximum. Output maximum current 2 milliamperes (determined by rectifier rating). Regulation: Internal

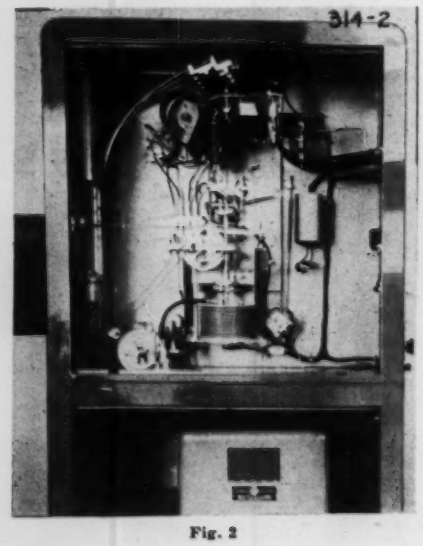
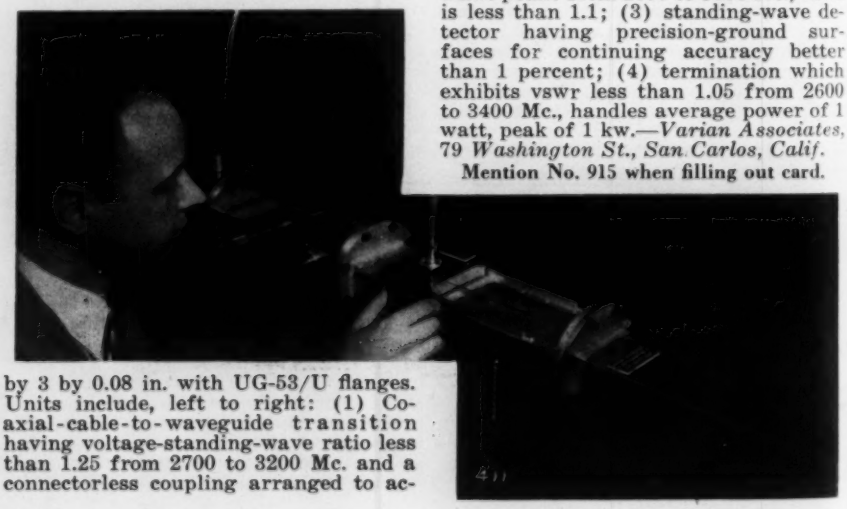


Fig. 2

Waveguide Test Equipment

New series of microwave test components is announced. Illustration shows a microwave test set-up which operates between 2600 and 3950 Mc. Waveguide is AN Type RG-48/U, 1.5



by 3 by 0.08 in. with UG-53/U flanges. Units include, left to right: (1) Coaxial-cable-to-waveguide transition having voltage-standing-wave ratio less than 1.25 from 2700 to 3200 Mc. and a connectorless coupling arranged to accommodate RG-5/U, RG-8/U, or RG-21/U flexible coax directly, utilizing inner conductor as probe; (2) variable attenuator with range from 0.5 db to 10 db and power rating of 1 watt average, 1 kw. peak: from 2600 to 3400 Mc., vswr is less than 1.1; (3) standing-wave detector having precision-ground surfaces for continuing accuracy better than 1 percent; (4) termination which exhibits vswr less than 1.05 from 2600 to 3400 Mc., handles average power of 1 watt, peak of 1 kw.—*Varian Associates,* 79 *Washington St., San Carlos, Calif.*

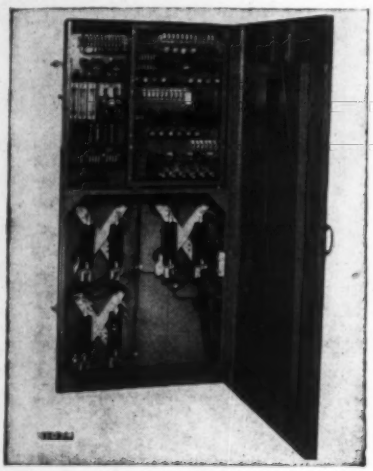
Mention No. 915 when filling out card.

resistance of approximately 8 megohms. Size 16 x 16 x 8 in.; weight 35 lbs. Other features: Choice of momentary high voltage or continuous high voltage by means of pushbuttons. For safety purposes, two pushbuttons, well separated, must be deliberately pressed to energize high voltage continuously. Control panel removable for remote operation. Variac current meter monitors high-voltage circuits; on special order, a load current meter can be substituted. —*Beta Electric Corp.*, 1762 *Third Ave., New York* 29, *N. Y.*

Mention No. 916 when filling out card.

Welding Controller

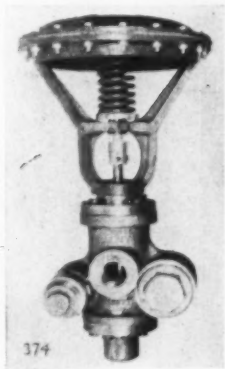
New three-phase low-frequency welding controller is designed to operate a welding transformer so as to draw power from a three-phase line and convert it to a lower-frequency single-phase and supply this to the electrodes of a resistance welder; reduces kva. demand for any given number of amperes at electrodes. Total power demand is spread over all phases of any standard three-phase, 60-cycle, 220-, 440- or 550-volt primary power source. Weld quality is better because wave shape obtained with three-phase control allows for a smooth flow of heat into metal. Packaged unit that controls all mechanical and electrical functions of the welding machine can be mounted on floor or on side of machine.—*Westinghouse Electric Corp., P.O. Box* 868, *Pittsburgh* 30, *Penna.*



Mention No. 917 when filling out card.

High-pressure Diaphragm-motor Valves

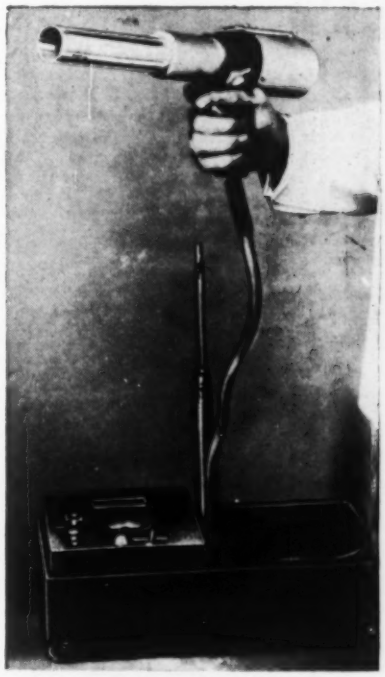
New complete line of diaphragm-actuated two-pressure valves, for a wide range of application in high-pressure hydraulic service, range in size from 1 to 4 inches; can be furnished for operation on 3000, 5000, and 10,000 psi. systems. Variations of valve assembly provide for (1) diaphragm-controlled high-pressure inlet, (2) diaphragm-controlled slow-travel valve, or (3) diaphragm-controlled stop valve, all handled within one casting and with minimum pipe connections. Feature is interchangeability of seats and disks between main valve and check valve assembly.—*Emmett Machine & Mfg., Inc.*, 2249-52 *Fourteenth St. S.W. Akron* 14, *Ohio.*



Mention No. 918 when filling out card.

Electrostatic Sampler for Dust and Smoke Measurements

New Electrostatic Sampler for quantitative sampling of airborne dusts, fumes, and smokes, is equipped with a portable sampling head for easy sampling of atmosphere at various levels. High-voltage cable facilitates coiling and permits use of an extension cable. Retractable stand provides support for sampling head when remote operation is unnecessary. Specially-designed power pack is capable of producing 10,000 to 15,000 volts d.c. Equipment is furnished in a portable case.—*Mine Safety Appliance Co., Braddock, Thomas and Meade Streets, Pittsburgh* 8, *Penna.*



Mention No. 920 when filling out card.

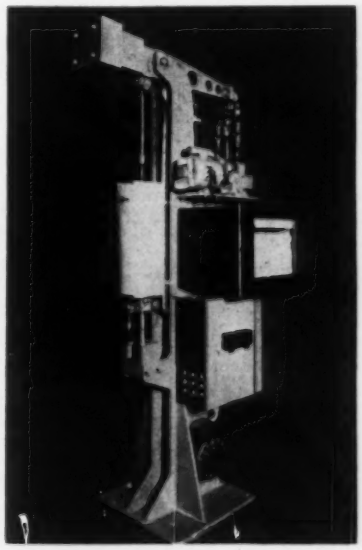
Automatic Inspector and Classifier for Bearing Races

New model of "Automatic Pneumatic Comparator Gage" measures bore taper and all finished dimensions on automotive roller bearing races simultaneously; furnishes a direct reading of taper variations as small as 0.00005 in.; and sorts pieces within five tolerances; speeds up to 1700 pieces per hour. Thickness, O.D., large I.D., and small I.D. are measured in one operation by separate air-gage components. Taper measurement is achieved by applying air gaging pressures of both large I.D. circuit and smal I.D. circuit to a differential-pressure transmitter; desired taper produces zero differential; deviations are indicated.—*Moore Products Co., H and Lycoming Streets, Philadelphia* 24, *Pa.*

Mention No. 919 when filling out card.

Relaxation Testing Machine

New 4000-lb.-capacity machine permits relaxation tests at temperatures up to 1800 F. to be carried out automatical-

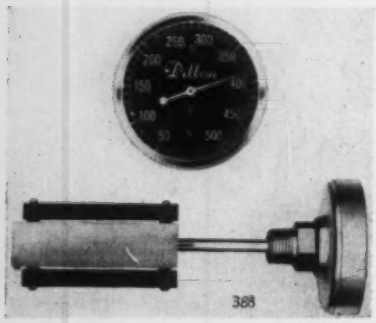


ly, including a record of rate of decline of load. It automatically relaxes tensional loads from as high as 40,000 psi. permitting strain increments of 2×10^{-6} in. per inch of 6-in. gage length of a standard 0.356-in.-diameter specimen. Increases in length are measured by an extensometer with electric contacts that command a servomotor to reduce load enough to open contacts again and thus maintain a substantially constant strain. Accuracy is held to approximately 1 percent of load or 0.25 percent of capacity. Recorder produces a curve of stress vs. time on a flat chart slightly less than 10-in. wide.—*The Baldwin Locomotive Works, Philadelphia* 42, *Penna.*

Mention No. 921 when filling out card.

Surface Thermometer

New "Flat-stem Magnetic Thermometer" is available in 1-in., 2¼-in., 3-in. and 5-in. dial diameters; stem lengths

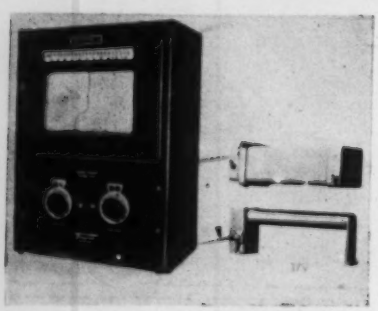


from 3 in. to 42 in.; nine ranges in F. or C. graduations; accuracy 1 percent of full-scale. Magnets enable operator to place thermometer on a flat surface and "peel" it off in a moment. Magnetic portion can be removed to permit instrument to be screwed into tanks, steam lines, etc.—*W. C. Dillon & Co., Inc.*, 5410 *W. Harrison St., Chicago* 44, *Illinois.*

Mention No. 922 when filling out card.

Radioactivity-principle Density and Thickness Gages

New "Beta Gauge" represents one of the first major industrial uses of Oak Ridge isotopes. Its essential components are a source of beta radiation from strontium-90 and a radiation detector. Sheet material to be measured is interposed between source and detector and a part of radiation is absorbed by sheet material in proportion to its weight per unit area. "Model SM-2" uses a Brown "Electronik" recorder and gage standardizes itself automatically every thirty minutes. Recorder scale can be calibrated in terms of a plus or minus deviation from specifications or as an absolute thickness or weight reading. Intrinsic accuracy of "Beta Gauge" is 0.05% of sample thickness or 0.03 mg./cm.^{2}, whichever is larger. Drift between standardizations is within limits of intrinsic accuracy of gage. Batteries require renewal no more often than three a year, eliminate need for a closely-regulated power supply. Maximum sensitive length of gage is 15 in.; minimum sensitive length is ¼ in. A non-recording industrial "Beta Gauge" and a "Laboratory Model Beta Gauge" are also available.—*Tracerlab Inc.*, 55 *Olive St., Boston* 10, *Mass.*



Mention No. 923 when filling out card.

Laboratory Water Stills

New "Streamliner" model laboratory water stills, said to be "the greatest improvement in water stills in twenty-five years," are constructed in three streamlined offset sections with vapor-tight sliding joints. They can be taken apart without tools in ten seconds. Among features: built-in after-cooler and large-diameter vapor flue with new improved

"Vapor-Maze" multiple baffles and vapor scrubber. Operation is continuous and automatic. Inlet water is used to cool condenser and is thus preheated to about 200 F. before entering evaporator. Electric-, gas-, and steam-heated models are available in capacities from 1 to 4 gpm.—*Precision Scientific Co.*, 3737 *W. Cortland St., Chicago* 47, *Ill.*

Mention No. 924 when filling out card.

Plug-in Amplifiers

New series of plug-in amplifiers, for use in computers and similar service, are available in three types, similar except for gain. Units contain three subminiature tubes: first two used as cascade amplifiers, third as a cathode follower. Input is connected to grid of the first tube. Amplification is substantially flat from 20 cps. into supersonic range. After assembly and test, the units are completely compounded to insure resistance to humidity and mechanical shock. Voltage gains of 10, 100 and 1000 are available and differentiated by different colors for aluminum shells. —*Walkirt Co.*, 5808 *Marilyn Avenue, Culver City, Calif.*

Mention No. 925 when filling out card.

Alarm Silencer

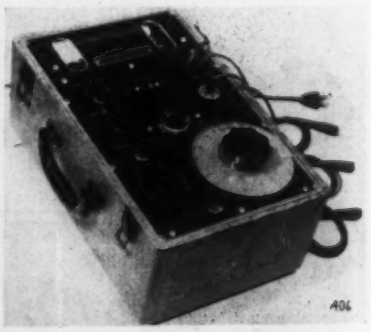
New "Type ABS Autocon Alarm Silencer" eliminates danger of forgetting to close hand-opened knife switches in alarm circuits; may be used with any type of circuit that indicates emergency conditions: pressure, liquid level, temperature, smoke, etc. It is designed to

provide continuous, complete protection even though warning sound is stopped. When emergency condition arises, alarm is stopped by pressing button on side of case. A glowing red light remains on until trouble is corrected. When circuit is clear, the silencer automatically resets itself and light goes out.—*Automatic Control Co.*, 1005 *University Ave. St. Paul, Minn.*

Mention No. 926 when filling out card.

Ohmmeter

New "Electronic Resistohmeter" is a Wheatstone bridge designed for measuring resistance and insulation resistance in both low and extremely high ranges. Balance indicator is a 6E5 elec-



tron ray tube, but sensitivity of bridge does not suffer and possibility of damage due to large unbalance is eliminated. Instrument is guarded internally so that humidity leakage across bridge components does not affect operation or accuracy of bridge. An external guard circuit guards specimens under test so that leakage across paths

other than the one under test is returned to a point in bridge where it has no effect upon test measurement. Accuracy is independent of power line voltage variations. Range: 1000 ohms to 100,000 megohms. Three test voltages: 10, 100 and 500. Unit operates on 115-volt 60-cycle, a.c.—*Crown Industrial Products Co., 1335 W. 69th St., Chicago, Ill.*

Mention No. 927 when filling out card.

Vacuum-control Switch

New "Model SM-3 Skanascope Electronic Vacuum Control" embodies numerous added features requested by customers and through added field application requirements: new model incorporates automatic line voltage regulation and a voltmeter to indicate trend while

system is activated. It will accommodate 1, 2, or 3 "Variable Sensing Tubes" of different ranges which may be permanently connected to system and any of which may be selected by a switch on front panel. A switch-over may be provided by added timer actuation if a fully automatic operation.—*Skaneateles Mfg. Co., Inc., Dickerson and Clinton Streets, Syracuse 2, N.Y.*

Mention No. 928 when filling out card.

Timers for Hazardous Locations

New "Microflex Timers" are announced for controlling electrically-operated valves and motors where atmosphere contains explosive mixtures. Cast-iron enclosure has a machined metal-to-

metal seal, making timer suitable for use in Class I Group D and Class II Group G hazardous locations. Standard dials are 120 seconds, 20 minutes, 120 minutes, 20 hours and 60 hours.—*Eagle Signal Corp., Moline, Illinois.*

Mention No. 929 when filling out card.

Weld Energy Comparator

New weld energy comparator has been designed to check weld energy consistency on applications where high-quality welds are a must, as in fabrication of high-alloy stainless steel used on jet engines. It can be used with any of maker's single-phase spot welding controllers; is provided with a sensitivity adjustment; detects changes in line voltage and changes in duration of welding current; is recommended for weld time ranges of 30 cycles and below. —*Westinghouse Electric Corp., Box 868, Pittsburgh 30, Penna.*

Mention No. 930 when filling out card.

Indicating Snap Gage

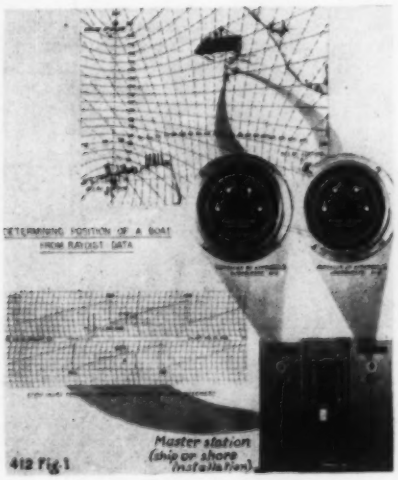
New "Model 1000 Dial Indicator Snap Gage" makes it possible for workmen accustomed to conventional "Go, No-go" gages to handle it in the same manner. A screw driver makes all size adjustments. Dial indicator has "Cushioned

Movement," can be faced in any position for machine or bench use. Contact point is spring-mounted and guarded from sidewise blows. Spring-loaded point also supports weight of hand and gage. Upper and lower contacts are tungsten carbide tipped. Five sizes cover all dimensions from 0 to 6 in.—*Federal Products Corp., 1144 Eddy St., Providence 1, R.I.*

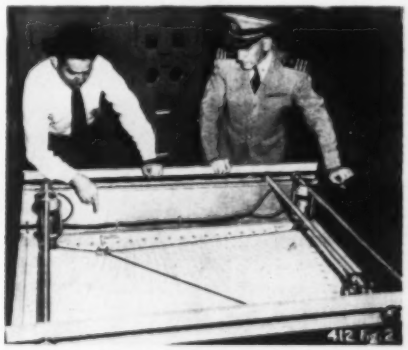
Mention No. 931 when filling out card.

Automatic Ship-position Plotting System

New "Raydist System" is a completely automatic plotting board on which a small ship with a recording pen attached moves on a chart or map to



show position of ship being tracked. Operation: a small radio transmitter installed on the full-size ship sends its signal to several receivers on shore. These signals are used to pin-point ship's location. Receivers in turn transmit their data to servomechanisms which move miniature ship and pen by means of flexible steel tapes to reproduce course of ship. By watching model maneuvering on chart, an observer on shore can follow exact course of a ship miles away. With plotting board installed on board ship, it will be possible to navigate narrow twisting channels under adverse weather conditions. "Raydist System" is accurate to one foot in a mile (0.019 percent). With plotting techniques used in normal navigation procedures, errors cannot be seen on chart. In recent tests under adverse weather conditions, "Raydist

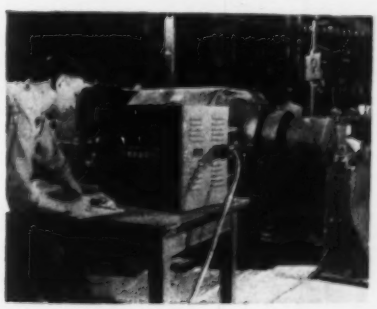


Systems" have tracked aircraft, vehicles, small boats and ships. Ranges of more than 100 miles have been attained at sea, maximum radiated power being only 10 watts. It is anticipated that "Raydist Systems" will be used also for oil exploration, hydrographic surveys, charting of rivers and channels, etc.—*Hastings Instrument Co., Inc., Box 1275, Hampton, Va.*

Mention No. 932 when filling out card.

Precision High-speed Tachometer

New tachometric equipment for accurate measurement of high speeds consists of a high-frequency pulse-generator type pick-up, an electronic counting circuit, and two speed-indicating units: one for on-the-spot readings and the other for remote readings. First announced model measures speeds from 0 to 17,000 rpm. Counting circuit is housed in a 200-lb. cabinet which measures about 5 x 2 x 1½ ft.; speed indicator is housed in a separate cabinet, approximately 2 x 2 x 1½ ft.; electromagnetic tachometer generator weighs about 5 lbs. and is approximately 6 x 8 x 4 in. 200 ft. of cable may be used



between tachometer generator and control cabinet, and another 200 ft. between control cabinet and indicating units.—*General Electric Co., Schenectady 5, N.Y.*

Mention No. 933 when filling out card.

Laboratory Dehumidifier

New Dehumidifier, capable of controlling moisture in a room of 8,000 cu. ft. volume, can eliminate the high humidity which is corrosive to laboratory equipment, objectionable in weighing deliquescent materials and enervating to laboratory personnel. It consists of

condensing and evaporating coils with motor-driven fan and receptacle for condensate, in housing 14 in. in diameter by 34 in. tall. In very humid conditions, it will remove 12 to 14 gals. of water per 24 hours. Its operation is recommended whenever dew-point is above 50 F. or dry-bulb reading above 65 F. Compressor is driven by 0.125-hp. motor; and fan which draws air into unit has a 0.01-hp. motor.—*Fisher Scientific Co., 717 Forbes Street, Pittsburgh 19, Penna.*

Mention No. 934 when filling out card.

Adjustable-speed Motor Drive

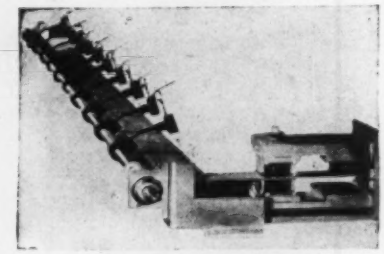
New fractional-hp. model of "Mot-O-Trol" packaged adjustable speed drive provides a wide, stepless range of speed control for d-c. motors from a-c. sources. It starts motors, brings them up to a pre-set speed smoothly and rapidly, permits change of speed at any time, applies dynamic braking for stopping, and reverses motors. A feature is that complete sub-assemblies can be removed for easy maintenance. A single dial gives finger-tip control of motor

throughout its entire speed range. Improved IR drop compensation provides a nearly flat speed-torque characteristic over entire speed range of drive. This compensating circuit is controlled by feedback from armature current.—*Westinghouse Electric Corp., Box 868, Pittsburgh 30, Penna.*

Mention No. 935 when filling out card.

Yarn Tensiometer

New yarn tensiometer provides quantitative data on tension conditions in textile spinning. Equipment consists of a shaft, bolted to frame in place of threadboard; an armature strip connected to shaft; two coils or strain gages forming a balanced circuit on either side of armature strip; and a power supply. Any pressure on yarn guides tends to rotate shaft; causing armature strip to move away from one coil face and nearer to the other, thus upsetting balanced circuit. Unbalanced

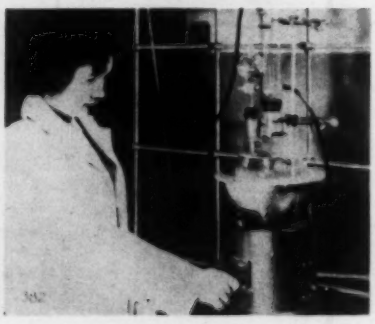


current is fed to a G-E photoelectric recorder or some other type of recorder of suitable sensitivity. Normally, unit is used measuring ten ends at once; dividing total by ten determines average tension. It can function, however, using only one end for gathering data on traveler or individual spindle performances. Ranges of sensitivity are readily adjustable by moving coils closer to or farther from armature, or by adjusting stiffness of blade.—*Special Products Div., General Electric Co., Schenectady 5, N.Y.*

Mention No. 936 when filling out card.

Magnetic Stirrer

New "Mag-Mix" magnetic stirring device, suitable for wide variety of beakers, flasks and other containers, operates on same principle as earlier models—producing agitation by means of induced magnetic force—but is more powerful: will stir liquids as viscous as S.A.E. 90 (at room temperature). Heavy-duty motor has permanent Alnico magnet attached to its shaft. Stirring bars placed in containers and on housing above revolving magnet are turned at any speed desired by adjusting external rheostat. Available stirring bars are enclosed in glass and in



acid-resistant plastic which can be employed at temperatures up to 300 C.—*Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Penna.*

Mention No. 937 when filling out card.

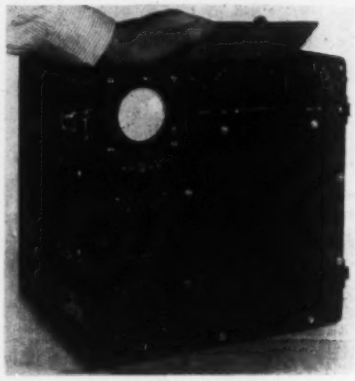
Relief Valve

New "No. 33 Safety Relief Valve" for hot water heating boilers conforms with current A.S.M.E. Boiler Code. Operating characteristics involve: (1) When set pressure of 30 psi. is reached, needle lifts just far enough to discharge water at low rate necessary to take care of thermal expansion of water; (2) if for any reason temperature rises into emergency zone, increased velocity acts on the "hydra-lift" ring, greatly increasing lifting power and snapping valve wide open to dissipate heat at high rate of 242,900 Btu. per hr. Testing lever operates independently of automatic pressure action so that it is not disturbed by opening of valve in service. Set opening pressure 30 psi. Tappings, Inlet, ¾-in. I.P.S., outlet 1-in. I.P.S.—*McDonnell & Miller, Inc., Wrigley Bldg., Chicago 11, Illinois.*

Mention No. 938 when filling out card.

Engine Analyzer

New "All-purpose Engine Analyzer" is portable version of maker's airborne engine analyzer to be used by ground

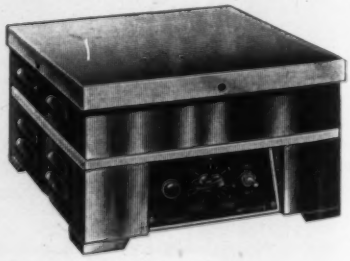


crews servicing fleets not equipped with flying model. It is applicable to any engine in airline service, to test stands and to fuel research projects. It permits complete surveys including vibration and detonation troubles as well as ignition troubles. Weight, 41 lbs.—*Sperry Gyroscope Co., Great Neck, N.Y.*

Mention No. 939 when filling out card.

Laboratory Hot Plate

New hot plate has temperature range of 140 to 850 F. (60 C. to 455 C.). Temperature is controlled by an input controller automatically compensated for line voltage variations. Built-in controls and supporting table or bench are pro-



tected from heat damage by 1½" of insulation underneath heating elements and by a system of baffles, louvers, and air channels which minimizes area for heat conduction and ventilates lower section in which controls are housed. Control panel is recessed into body. Other features include: stainless steel body; conductive cast-aluminum top plate; heating elements coiled from nickel-chromium alloy with low ratio of watts to surface area. Two sizes are available: 12 in. x 12 in. and 12 in. x 24 in. and separate units are built for operation on 115 and 230 volts, 50/60 cy. a.c.—*Thermo Electric Mfg. Co.*, 496 *W. Locust Street, Dubuque, Iowa.*

Mention No. 940 when filling out card.

Exposure Meter for Polaroid Camera

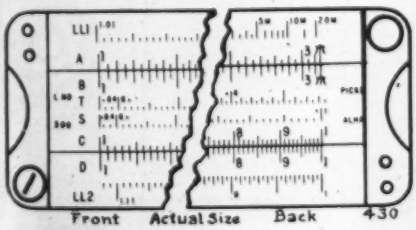
New "PR-22" exposure meter designed at request of Polaroid Corp. for use with its "print-a-minute" Land Camera, is calibrated in numbers from 1 to 8 to correspond with settings on Land

Camera; is not suitable for use with conventional cameras unless a conversion table or special calculator is used. It can be used to measure scene brightness over a range of 12 to 1600 candles per square foot. Film speeds are set by rotating dial to letter of film being used. —Manufactured by *General Electric Co.*; sold by *Polaroid Corp.* through its dealers.

Mention No. 941 when filling out card.

Six-inch 16-scale Log-slide Slide Rule

"Model 300" 6-inch duplex type all-metal slide rule, bearing regular 10-inch log log scale arrangement, incorporates features not available before in a 6-inch rule: (1) 16-scale arrangement: front: LL1, A-B, T, S, C-D, LL2; back: LL3, DF-CF, CIF, CI, C-D, L; (2) Dimen-

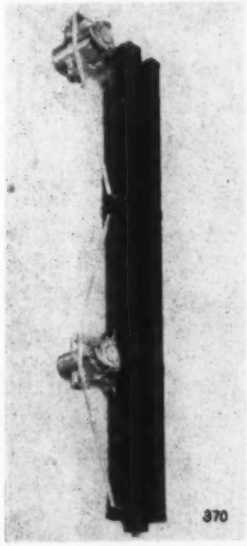


sionally stable magnesium alloy body, tongues and grooves machined to 0.001 in.; (3) Needle-sharp graduations on scales optically-spaced for easy reading, computational accuracy comparable with that made on a 10-inch rule; (4) Combination of C-D scales on both sides, together with folded and reverse scales, speeds figuring and avoids going "off-scale." Instruction Manual by Prof. M. L. Hartung; and full leather pocket case.—*Pickett & Eckel, Inc.*, 5 *S. Wabash, Chicago* 3, *Ill.*

Mention No. 942 when filling out card.

Gage Illuminators

New "Solid-Wedge Type Gage Illuminators" give evenly-diffused light over entire length of gage glass with no glare spots or blinding areas; are made

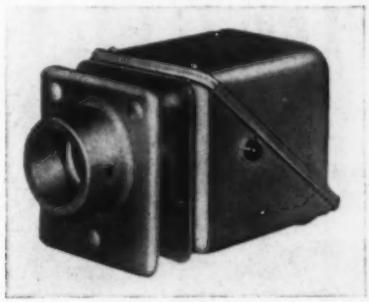


in both explosion-proof and standard models, and in both single- and double-section styles.—*Jerguson Gage & Valve Co.*, 80 *Fellsway, Somerville* 45, *Mass.*

Mention No. 943 when filling out card.

Flame Failure Safeguard

New "Fireye Flame Failure Safeguard Type F18T-2" provides operating flame failure protection for manually-ignited oil burners, air heaters, ovens, kilns, etc., can be used with programming controls to protect automatically-ignited



oil burner installations. On existing installations, it may be readily substituted for slower-acting devices to give increased flame protection. Control is approved by all insurance laboratories. —*Combustion Control Corp.*, 77 *Broadway, Cambridge* 42, *Mass.*

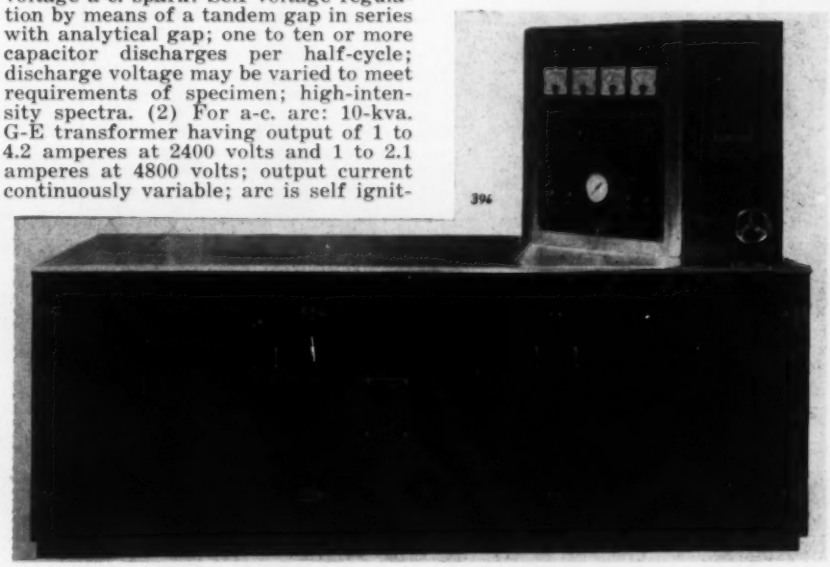
Mention No. 944 when filling out card.

Nitrogen Dioxide Detector

New portable nitrogen dioxide detector is said to determine nitrogen dioxide concentrations from 1 to 500 p.p.m. more conveniently and in a much shorter period than previously possible. Kit contains reagent bottles, sampling syringes, color plaques and directions. Reagents are solutions of sulfanilic acid and alphanaphthylamine previously prepared in user's laboratory. Before making a test (in an uncontaminated at-

Spectrograph Source Unit

New "Spec-Power," an electric source unit for providing current to burn spectrographic samples, provides three power circuits in a single case, all circuits operating from a single control panel which includes an oscilloscope, ammeters, voltmeters, preburn and total exposure timers, and all necessary control switches. Circuit designs contribute to reproducibility of spectra. Among features of each circuit: (1) For high-voltage a-c. spark: Self voltage regulation by means of a tandem gap in series with analytical gap; one to ten or more capacitor discharges per half-cycle; discharge voltage may be varied to meet requirements of specimen; high-intensity spectra. (2) For a-c. arc: 10-kva. G-E transformer having output of 1 to 4.2 amperes at 2400 volts and 1 to 2.1 amperes at 4800 volts; output current continuously variable; arc is self ignit-



ing at 4800 volts. (3) For d-c. arc: Full-wave rectification provides output of 3 to 30 amperes at 250 volts; heavy-duty choke coil in secondary reduces ripple to less than 10 percent; all components designed to operate at peak capacity without excess heating. — *National Spectographic Labs., Inc.*, 6300 *Euclid Ave., Cleveland* 3, *Ohio.*

Mention No. 945 when filling out card.

INSTANTANEOUS

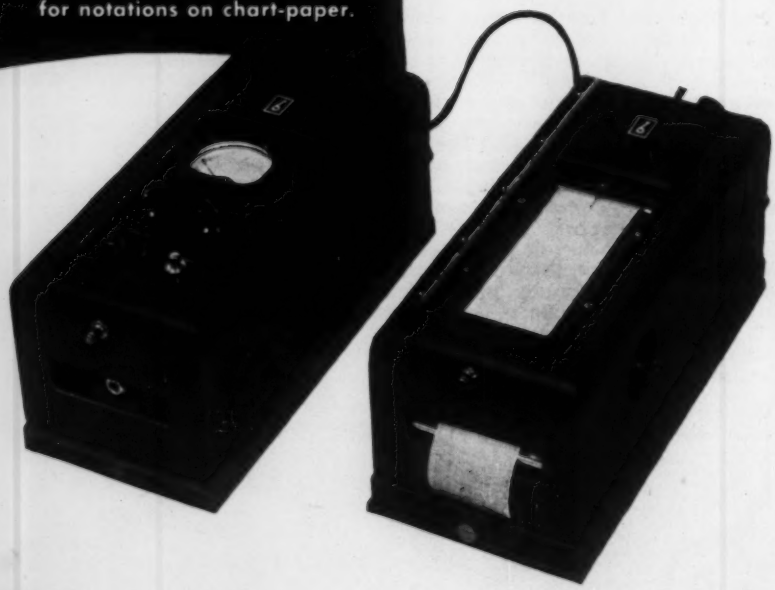
recordings from D.C. to 100 cps!

Accurate recordings of voltages, pressures, strains, vibrations and countless other phenomena.

Permanent ink on paper recordings by Brush Oscillographs make their use almost unlimited.

Either A. C. or D. C. signals can be measured. Whenever desired, recordings may be stopped for notations on chart-paper.

• Investigate Brush measuring devices before you buy . . . they offer more for your money . . Why not have a Brush field engineer call? At no obligation, of course. Just call or write . . today . . you will find it worth a few seconds' time!



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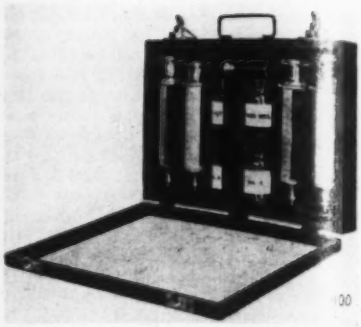
Canadian Representatives: A. C. Wickman, (Canada) Ltd., P. O. Box 9, Station N, Toronto 14

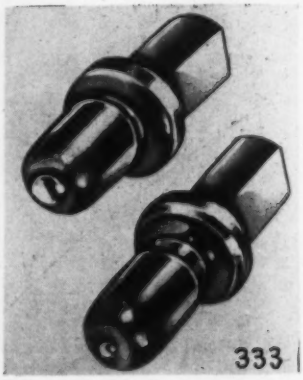


mosphere) these reagents are combined in equal amounts in sampling syringes. In suspected area, a syringe is uncapped and a measured quantity of air is sampled. Ten minutes after cap has been replaced and syringe shaken, reading can be made by comparing color of solution with standard color plaques.—*Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh 8, Pa.*

Mention No. 946 when filling out card.

Steel-ball Penetrators for Rockwell Hardness Testers

New steel ball penetrators, designed for all makes of Rockwell testing machines, are ground to a precise roundness, providing smooth, even penetration

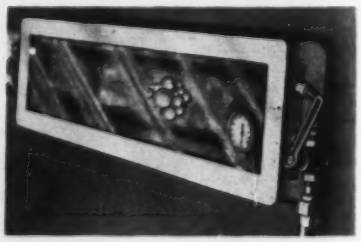


said to assure unusually accurate readings. New penetrators are available in 1/16, ⅛, ¼ and ½-inch sizes, and are used with Rockwell scales B, E, F, G, H, K, L, M, P, R, S, V, 15-T, 30-T and 45-T. —*Clark Instrument Co., Inc.*, 10200 *Ford Road, Dearborn, Mich.*

Mention No. 947 when filling out card.

Leak Detector

New "American Vacuum Seam Tester" for quickly locating leaks in pipes, tanks or other storage vessels is a portable unit which effects savings by obviating need of taking old equipment out of service. In construction of new tanks and storage vessels, it detects even pin-point leaks. Tester oper-

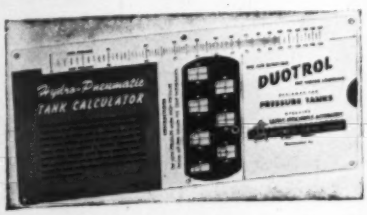


ates on vacuum principle. Seams are covered with soap suds; inspection box, with clear glass top and soft rubber base, is laid over seam; vacuum created within inspection box draws air through any leaks, causing soap bubbles to form and be seen through glass top. Testers are available in a wide variety of sizes and shapes for inside corners, outside corners, circumferential seams and straight seams.—*American Pipe & Steel Corp.*, 2201 *West Commonwealth Ave., Alhambra, Calif.*

Mention No. 948 when filling out card.

Hydro-pneumatic Tank Calculator

New "Autocon Hydro-pneumatic Tank Calculator" gives accurate determination of best high water level in pressure tanks under all operating con-

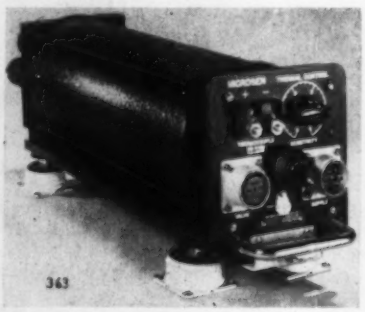


ditions; is based on the Boyle's Law; instantly tells best air-water ratio, most efficient pressure differential, amount withdrawn on any pressure drop, and resultant reserve or residual. Size, 4 in. x 9 in.—*Automatic Control Co.*, 1005 *University Ave., St. Paul* 4, *Minn.*

Mention No. 949 when filling out card.

Aircraft Control Amplifier

New "Type 141 Microsen Control Amplifier," designed to meet stringent aircraft ambient conditions, includes highly-sensitive electromechanical "Microsen" d-c. amplifier as an input circuit and a power output stage to drive a two-phase 400-cycle servomotor. De-



pending upon requirements of control problem, either derivative or integral stabilizing signals may readily be introduced. Low-level error detecting devices such as thermocouples, strain-gage bridges and photocells make excellent input devices because of high sensitivity and stability of "Microsen" input stage. Shock mounted structure is hermetically sealed and pressurized.—*Manning, Maxwell & Moore, Inc., Bridgeport, Conn.*

Mention No. 950 when filling out card.

Spring Tester

New spring testing machine is designed for high production inspection and testing of any type of small spring (coil, flat, special design, or spring assembly) within limits of 12-in. length

New "Contour Analyzer" measures and records displacements from 10 to 10,000 microinches!

"Contour Analyzer" consisting of pickup head, BL-309 Amplifier and Brush Direct-Inking Oscillograph.

SPECIFICATIONS

Displacements measurable	10 to 10,000 microinches
Frequency Response (overall)	Essentially uniform DC to 100 cps
Feeler Arm Travel	.015" approximately
Feeler Arm Force	Adjustable
Minimum	approximately 1½ oz.
Amplifier Dimensions	Length 17¼", Width 11", Height 7½"
Amplifier Power Requirements	100 watts

The "Contour Analyzer" is an instrument designed to record small displacements from a given reference point or line. Its sensitivity is such that movements as small as 10 microinches can be readily recorded and measured on the chart of the Brush Direct Inking Oscillograph. It can be used in a great number of applications involving small displacements, static or dynamic. Typical uses are as a recording micrometer, vibration recorder, pressure and force recorder, etc. In particular, the instrument lends itself well to the measurement of errors in the contour of irregularly shaped sections.

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RESISTANCE MEASUREMENTS

. . . with the Rubicon
PORTABLE WHEATSTONE BRIDGE

This convenient instrument combines instant portability with high accuracy and is widely used in laboratory, plant and field. Built for dependable service under hard usage.

- Wide range: 1 ohm to 10 megohms
- Limit of error: 0.1%
- Built-in battery and galvanometer
- Provision for external battery and galvanometer when required
- Available with Murray and Varley loop circuits
- Compact and rugged

. . . with the Rubicon
PORTABLE KELVIN BRIDGE

For work at very low resistance levels this instrument is the counterpart of the Wheatstone bridge shown above.

- Range: 0.0001 to 10.1 ohms
- Limit of error: 0.25%
- Built-in battery and high sensitivity "Pointerlite" galvanometer
- Provision for external battery and galvanometer when required
- Sturdy and convenient in operation

Wheatstone and Kelvin bridges in a variety of models, together with other resistance measuring instruments, are fully described in Bulletin 100 available on request.

SPOTLIGHT GALVANOMETER

- Sturdy, short period
- Sensitive (up to 0.0006 μA per mm.)
- Multiple-reflection optical system
- For null or deflection measurements

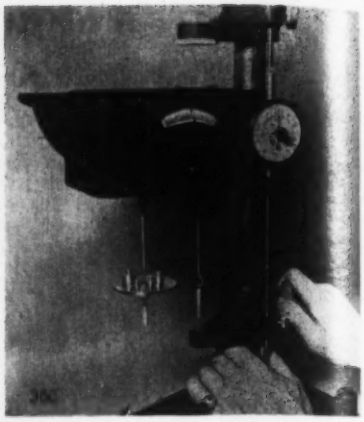
Described in Bulletin 320

•

OTHER RUBICON INSTRUMENTS

Resistance Standards • Mueller Bridges • Precision Potentiometers • Evelyn Photoelectric Colorimeter for chemical analysis • Automatic Recording Photometric Analyzers for NO and H_2S • Magnetic Permeameters • Magnetic Hardness Testers • Shorted-Turn Coil Testers • Other equipment involving precise measurement of electrical quantities.

RUBICON COMPANY
Electrical Instrument Makers
3755 Ridge Ave. • Philadelphia 32, Pa.



and 5-lb. load; is sensitive to load changes of less than 50 milligrams and has a weighing accuracy within 0.1 percent; indicates whether or not spring is within design tolerance limits. Vernier adjustments of compression and extension heads enable fast determination of compressed or extended lengths of springs for a given load to 0.001 inch.—*The Baldwin Locomotive Works, Philadelphia* 42, *Penna.*

Mention No. 951 when filling out card.

Photoelectric Colorimeter

New "Model 8 Photoelectric Colorimeter" is a filter colorimeter in which have been incorporated many features of maker's diffraction-grating spectrophotometers, including: (1) taut-suspension galvanometer; (2) dual capability of direct-deflection reading, for speed, and potentiometric balance for precision; (3) removable and interchangeable scale panels; (4) wide choice of cuvettes; (5) set of carefully-selected and rigidly-mounted optical filters. —*Coleman Instruments, Inc.*, 318 *Madison St., Maywood, Ill.*

Mention No. 952 when filling out card.

Three-way Solenoid Valves

New "Series M-3" line of three-way bronze body solenoid valves are designed for use with petroleum oils, kero-

sene, gasoline, water, air and inert gases with operating pressures from 20 to 150 psi. Normally-open, normally-closed, and directional-flow-control types are available with full ⅜-in. orifice and ⅜-in. or ½-in. N.P.T. ports. Soft synthetic inserts prevent leakage. A spring-loaded pilot insures positive closing with valve mounted in any position. All valves may be used for continuous or intermittent duty; have been operated up to 300 cycles per minute on air. New valves are 5½ in. high, weigh approx. 3¾ lbs. Maximum power consumption is 10 watts.—*Skinner Electric Valve Div., Skinner Chuck Co., Norwalk, Conn.*

Mention No. 953 when filling out card.

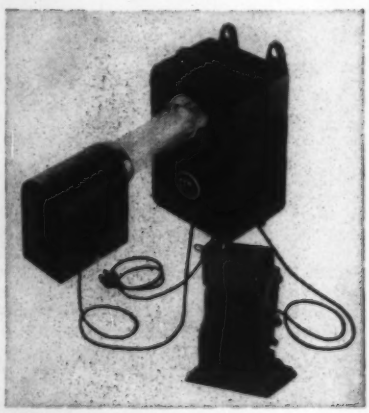
Pressure Gage

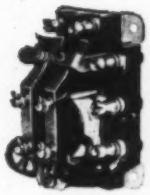
New 3½-in. unit, added to maker's "Helicoid Gage" line, has steel Bourdon tube, is particularly suitable for ammonia ice machines, pumps, compressors, and hydraulic presses up to 10,000 psi. Same features as maker's larger gages: "Helicoid Movement," stainless steel bearings, Korex steel Bourdon tubes, fused joints, and external pointer adjuster.—*Helicoid Gage Div., Am. Chain & Cable Co., Inc., Bridgeport 2, Conn.*

Mention No. 954 when filling out card.

Photoelectric Counters

New "Photoelectric Counter Set P-1," said to be "used in every industry," consists of photoelectric control, light source, and one or more electric counters (containing counter face and reset knob) which may be placed at any convenient location. No wiring is necessary: control has a line cord with a male plug which fits any standard lighting outlet; light source and electric counter have cables and plugs for plug-in connection to control; entire equip-



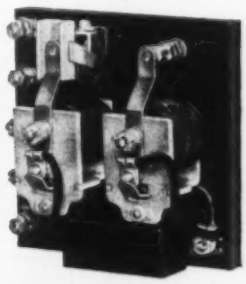


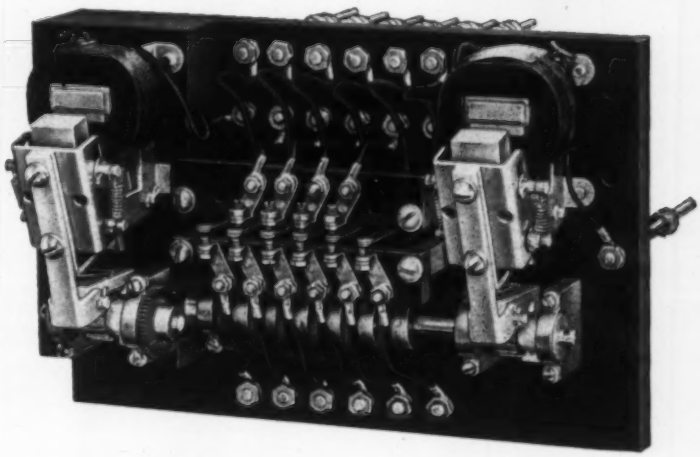
STANDARD RELAYS

. . . thousands of available types, electrically and mechanically adapted for every-day relay applications.

SPECIAL RELAYS

. . . types that have never been made before—for jobs that have never been done before.





BIG RELAYS OR LITTLE RELAYS

As specialists in relay design and manufacture, Struthers-Dunn has ranged from turning out 20,000 "production relays" a week to devoting a year for the development of a single highly-specialized type.

Twenty-seven years of experience in designing and building thousands of different relay types—for as many different applications—is available to help solve your relay problems.

Write for Catalog "G"—a quick, handy guide to the most widely used Struthers-Dunn relay types.

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5,348 RELAY TYPES

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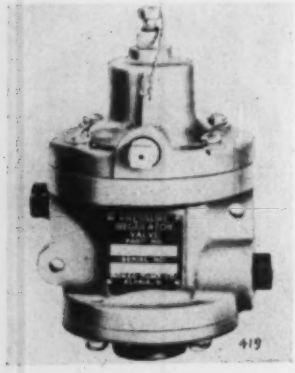
ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

ment, therefore, can be installed quickly without help of electrician. Speed of operation: up to 600 counts per minute. Range: 6 feet between photoelectric units and light source. (Special light sources available for longer range.)—*Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.*

Mention No. 955 when filling out card.

Pressure-regulator Valve

New pressure regulator valve for water and fuel systems reduces pressures of as high as 100 psi. to any constant lower pressure. Valve compen-



sates for variations in liquid fuel or water consumption by holding outlet pressure within narrow limits. Owing to its pressure-reducing action, valve operates under conditions of variable inlet pressure by throttling passage of flow in feed line. For aircraft, valve is designed as a balanced valve with turbo supercharger connection which balances valve pressure with air induction system of engine for operation from sea level to 40,000 feet. Weighs 15½ oz. in ⅜-inch port size. Parts replaceable without removing valve from system.—*Romec Div., Lear, Inc., Elyria, Ohio.*

Mention No. 956 when filling out card.

X-ray Dosimeter

New "Integron IV" for x-ray dosage measurement is particularly designed for flexibility of operation. Scale is calibrated from 0 to 500 roentgens and requires only one control knob on panel. Floor pedestal is portable, easily adjusted for positioning chamber tube, is streamlined and light in construction. Provision has been made to dispense with base pedestal and mount chamber

tube conveniently on newer types of therapy equipment. Instrument incorporates new electronic principles which eliminate rotating or moving components. It solves insidious problem of leakage caused by dirt, lint, or humidity; ionization chamber tube is hermetically sealed.—*The Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

Mention No. 957 when filling out card.

Radioactivity Scaler and Ratemeter

New "Raychronometer" is a combination automatic scaling instrument and counting ratemeter for precise measurement of radioactivity with Geiger tubes. It contains a scale of 10,000 for collecting a predetermined number of counts; a regulated Geiger tube voltage supply variable from 500 to 2500 volts; a syn-

chronous-motor-driven computer to solve count/time ratio; Geiger tube fusing circuits as protection against continuous discharge; and an integrating type of counting ratemeter. Geiger tube voltage supply may also be operated as a pulse-amplitude-regulated system which regulates against changes in threshold voltage of tube. Temperature effects are thus minimized as variables in counting procedure.—*Radioactive Products, Inc., 3201 E. Woodbridge St., Detroit 7, Mich.*

Mention No. 958 when filling out card.

Three-inch Oscillograph Tube

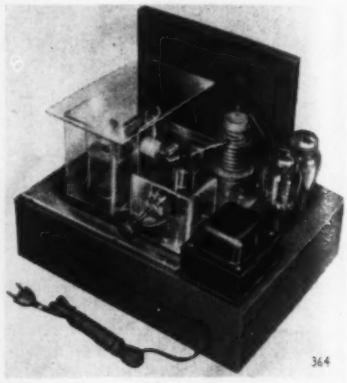
New "3KP11" 3-inch oscillograph tube is intended particularly for photographic recording of electrical phenomena. Blue radiation of fluorescent screen is highly actinic and has sufficiently short persistence for moving-film re-

cording without blurring except where film moves at high speed. Tube is suitable for visual observation of phenomena because it utilizes an improved phosphor having unusually high brightness for a blue screen. It is interchangeable with and like "3KP1" except for its screen characteristics. It has electrostatic focus, electrostatic deflection, high deflection sensitivity, and a "zero current to 1st anode" gun. Spot can be sharply focused both at center and at edges, remains sharp when beam current is varied over a wide range.—*Tube Dep't., Radio Corporation of America, Harrison, N.J.*

Mention No. 959 when filling out card.

R-f. Power Supply

New completely enclosed 30-k[illegible] r-f. power supply is suitable for insu[illegible]ation breakdown tests, dust precipi[illegible]tion, electrostatic painting, and pro[illegible]ction television. Power up to 500 mic[illegible]am-

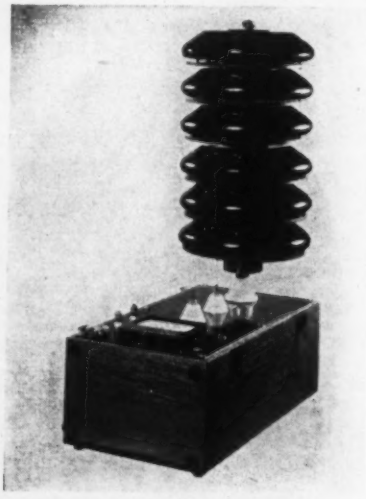


peres may be drawn with good regulation. Unit is said to feature unusual stability. It includes low-voltage d-c. supply. Voltage is variable from 15 kv. to 30 kv. through a control on front panel.—*Spellman Television Co., Inc., 130 W. 24th St., New York 11, N.Y.*

Mention No. 960 when filling out card.

Range Extending Device for Portable Kilovoltmeters

New method of extending range of maker's portable kilovoltmeters does not require internal changes. By means of a machined fitting which attaches

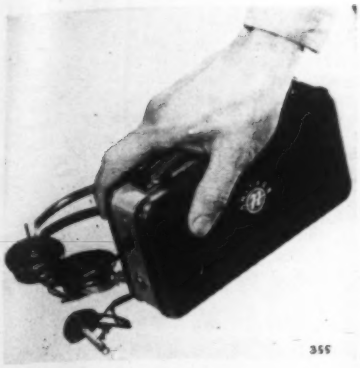


to highest-range binding post, from one to six "No. 505 Corona Protected Resistors" can be added to increase range of instrument as required. Each resistor weighs a little over two pounds. Complete resistor sets are supplied in a carrying case on special order.—*Shallcross Mfg. Co., Collingdale, Penna.*

Mention No. 961 when filling out card.

2-lb. Radiation Detector

New "Sniffer" is described as "an extra-convenient Geiger counter that allows every fisherman, camper, or vacationer to get in on the hunt for uranium." It weighs two pounds and is the size of a folding camera. It is claimed to "obtain up to 1200 volts from only

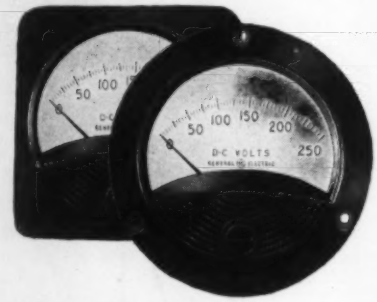


two 10c flashlight batteries." No other battery supply is needed.—*Nuclear Instrument and Chemical Corp., 223 West Erie St., Chicago 10, Illinois.*

Mention No. 962 when filling out card.

Electrical Indicating Instruments

New line of 2½-inch panel instruments comprises Types "DW-71" (direct current), "DW-72" (thermocouple), "DW-73" (rectifier), and "AW-72" (iron-vane), feature stylized cases, ta-



pered pointers, and scales with large, easy-to-read numerals. They are available in either round or square cases in all preferred ratings. Instruments are housed in dust-proof and moisture-resisting molded Textolite cases; the instruments are accurate within plus or minus 2 percent.—*Meter and Instrument Div., General Electric Co., West Lynn 3, Mass.*

Mention No. 963 when filling out card.

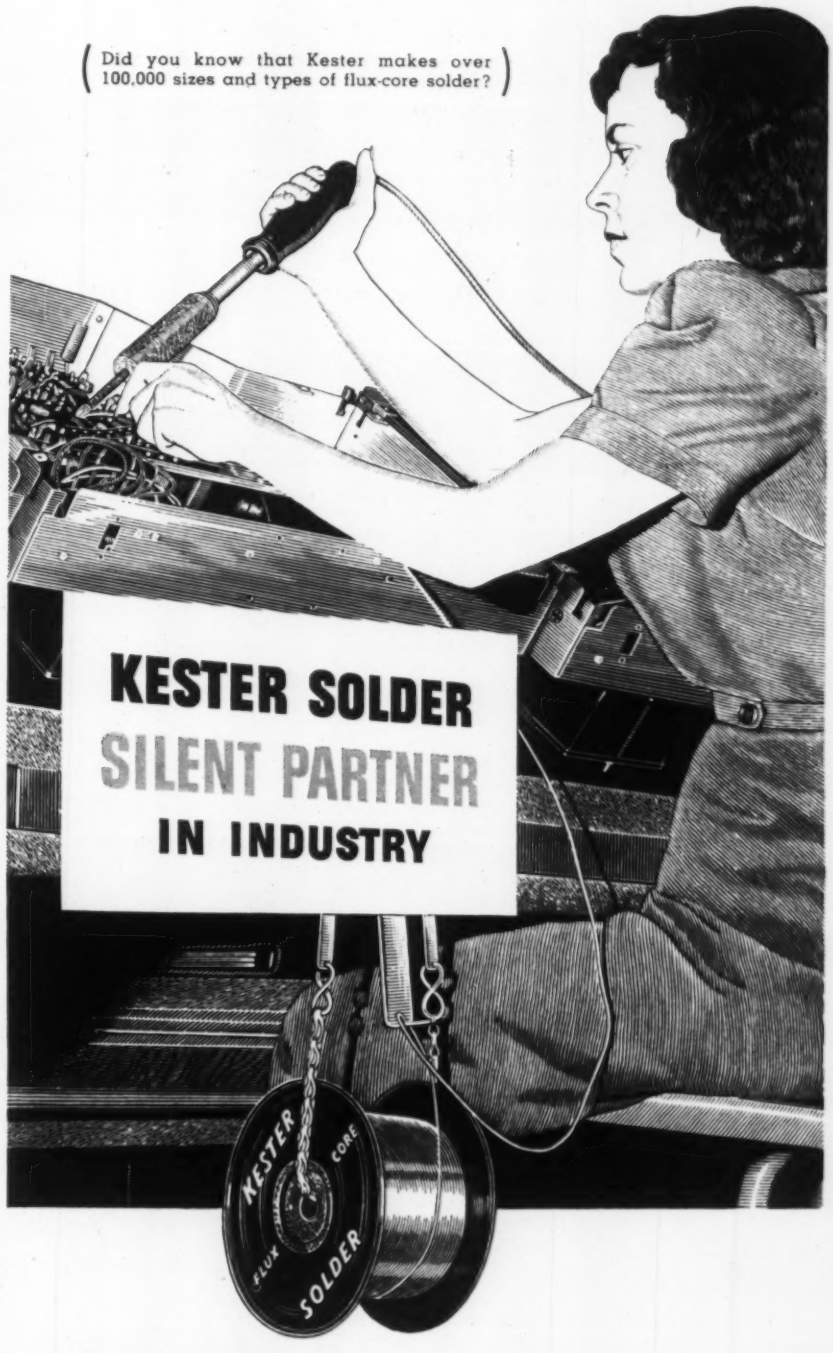
D-c. Power Supply

CORRECTION.—Output of "Model 245" (Kepco Labs.) described in our July issue, page 602, is 200 to 450 volts at 0 to 200 milliamperes.

Standard Potential Source

New "Model 23 Galivolter" is a laboratory standard source of potential for use in calibration of amplifiers, indicating and recording systems, transformer gains, etc., from d.c. to 100,000 c.p.s., when powered by a suitable battery or oscillator. Potentials ranging

Did you know that Kester makes over 100,000 sizes and types of flux-core solder?



For over fifty years Kester has been concerned with producing solder for every phase of industrial work. Take advantage of this experience by consulting Kester's Technical Department on all soldering problems. There is no obligation.

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FarriSeal is the valve that's winning new friends in the Petrochemical industries, because FARRISEAL is the only Safety-Relief Valve protected from corrosion by stainless steel armor.* That's why the FARRISEAL is safe—sure to open at the set pressure, even under corrosive conditions which make ordinary valves dangerous.

The FARRISEAL Bellows effectively isolates and fully protects the heart of this popular valve from the action of acids, caustics and other corrosive materials. It makes possible substantial savings in operating, maintenance and replacement costs.

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Proof of dependability of the FARRISEAL Bellows-Protected Valve is amply provided by hundreds of successful installations, including some of the largest and most important refineries and chemical plants.

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from 1 microvolt to 1 volt are obtainable by direct-reading of a continuously-variable dial in five ranges conveniently overlapped for maximum precision in setting required voltage. Since output is obtained from a circuit whose impedance varies from 1 ohm to 10 ohms, instrument is useful in calibrating circuits having a low input impedance. Instrument's high range may be increased by plugging in standard resistors.—*The Calidyne Co., 75 Main St., Winchester, Mass.*

Mention No. 964 when filling out card.

TV-FM Sweep Generator

New "Model 3434" Sweep Generator is said to provide a complete service laboratory for TV and FM servicing and other electronic requirements. Continuous ranges to 240 Mc. cover all TV

carrier and i-f. frequencies. There are no gaps in frequency. Continuous tuning is provided over all TV and FM bands. Sweep width: 0-12 Mc. (continuously variable). Two built-in markers can be used simultaneously: 19.5-40 Mc. marker frequency for i.f.; 57-240 Mc. for r.f. and oscillator. Marker has both pip and absorption dip control.—*The Triplett Electrical Instrument Co., Bluffton, Ohio.*

Mention No. 965 when filling out card.

Wide-range Oscillator

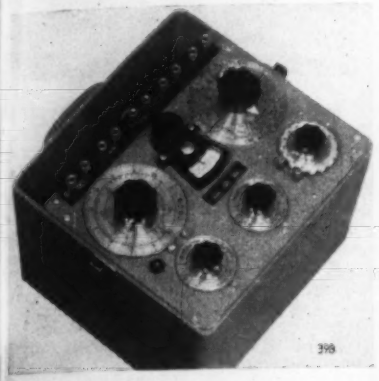
New "Model M" oscillator, developed to meet exacting demands of geophysical research laboratories, features a unique circuit which has no lower limit to its possible frequency of oscillation. Other features: (1) Extremely low dis-

tortion; (2) extremely high calibration accuracy; (3) power frequency comparator; (4) fixed frequency crystal plug-in units; (5) unusually wide frequency range; (6) unusually high output; (7) regulated power supply; (8) higher quality components than are found on production type oscillators; (9) custom manufacture and testing.—*Southwestern Industrial Electronic Co., P.O. Box 13058, Houston 19, Texas.*

Mention No. 966 when filling out card.

Universal Impedance Bridge

New "Model 250-A Universal Impedance Bridge," featuring conveniently small size and light weight, is said to provide unusually high accuracy by utilizing 0.1% precision wire wound resistors in bridge arms and a unique directly-calibrated slide-wire consisting



of a 0.1% precision decade with a coaxially-mounted single-turn rheostat for interpolation within decade steps. Measurement ranges: resistance: 1 milliohm to 1 megohm; capacitance: 1 microfarad to 100 microfarads; inductance: 1 microhenry to 100 henries; storage factor (Q=X/R) 0.02 to 1000; dissipation factor (D=R/X) 0.002 to 1.—*Brown Electro-Measurement Corp., 4635-37 S.E. Hawthorne Blvd., Portland 15, Oregon.*

Mention No. 967 when filling out card.

Sweeping Oscillator

New "Calibrated Mega-Sweep" makes it possible to tune with single knob over entire frequency range, approx. 50

kc. to 1000 Mc. Tuning is accomplished without re-peaking klystron beat frequency oscillators. Dial indicates center frequency of sweep to within accuracy of sweep width. Improved instrument is built to same specifications as "Mega-Sweep."—*Kay Electric Co., Pine Brook, N.J.*

Mention No. 968 when filling out card.

Radio Transmission Measuring Set

New "Type 11A" moderate-priced transmission measuring set, said to incorporate many features employed in many expensive models, may be used to

How SPEED helped catch "bugs" in the lacquer

Final finish on pianos mysteriously going "sour." Production halted. Lab needed X-ray diffraction camera to identify impurity. At 9 A.M., 10-lb. camera Air Expressed from 1100 miles away, delivered by 4 P.M. *same day*. Cost, only $3.58. Company uses Air Express as routine method to get supplies fast, keep inventory low.

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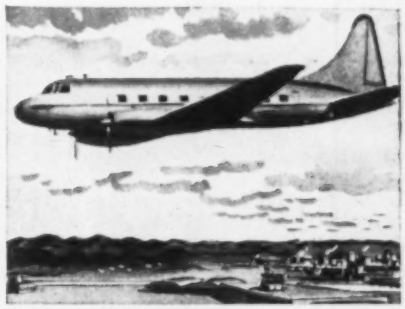

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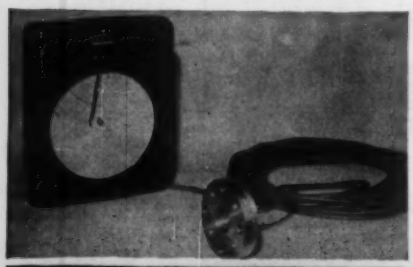

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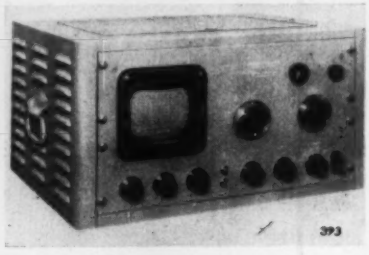
make all the precise measurements required by the FCC. It is designed for specific use in checking frequency response, impedance-matching characteristics and gain and loss measurements. Accuracy: 1 percent; frequency range: 20-20,000 cps.; attenuation range: measurements can be made to 111 db in steps of 0.1 db.—*Daven Co.*, 191 *Central Ave., Newark, N.J.*

Mention No. 969 when filling out card.

Ultrasonic Analyzer

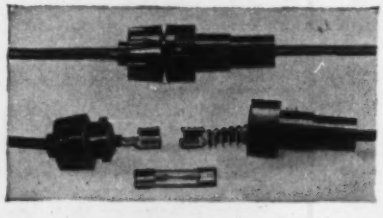
New "Model SB-7 Panoramic Ultrasonic Analyzer," said to "revolutionize the technique of ultrasonic spectrum analysis," is an electronically-tuned receiver in which output is applied to a cathode-ray tube oscilloscope. As instrument scans through, a series of corresponding vertical deflections appear as inverted Vs on 'scope screen. By synchronizing timing with horizontal sweep of 'scope, horizontal location of each deflection indicates frequency of its corresponding signal, making it possible to observe and study many signals at one time.—*Panoramic Radio Products, Inc.*, 10 *South Second Avenue, Mount Vernon, N.Y.*



Mention No. 970 when filling out card.

Instrument Fuse Holder

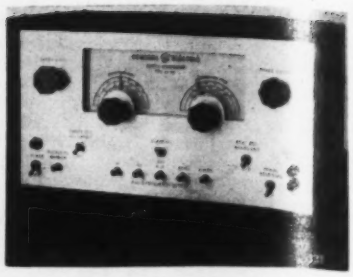
New in-the-line fuse holder utilizes principle of a tube socket contact of proper diameter. Positive contact is assured by attaching wire lead to socket-type contact by a solderless crimp connection. Considerable savings in assembly time are made possible. After three insertions of a 0.253-in. (plus or minus 0.0005) diameter pin, maximum voltage drop is five millivolts at 20 amperes when measured with a 0.247-in. (plus or minus 0.0005) silver-plated copper pin. Strong molded cap locks securely and unlocks easily.—*Hugh H. Eby, Inc.*, 4712 *Stenton Avenue, Philadelphia, Penna.*



Mention No. 971 when filling out card.

Sweep Generator

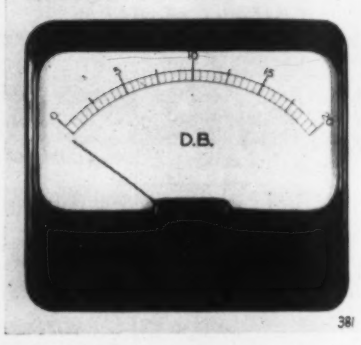
New "Type ST-4A" electronic sweep generator, using a variable-permeability type sweep and having no moving components, is designed for use in laboratories, for production testing and maintenance of TV equipment. Its frequency is continuously variable from 4 to 110 Mc. and from 170 to 220 Mc. with a linear sweep width from 50 kc. to greater than 15 Mc. Attenuation is continuously variable from maximum output down to 20 microvolts. Leakage is low: stray fields of less than 10 microvolts induced in a 2-inch loop six inches from the case in any direction.—*Special Products Division, General Electric Co., Electronics Park, Syracuse, N.Y.*



Mention No. 972 when filling out card.

Phonograph Disk Noise Meter

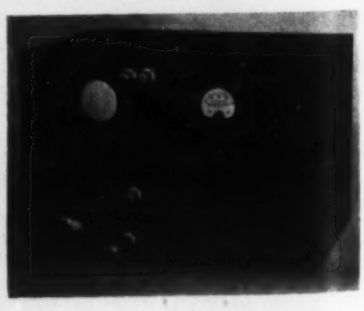
New "Model 140 Disc-Noise Meter," first commercially available device for checking noise level of lacquer disks and test pressings, consists of high-gain preamplifier, monitor amplifier, new logarithmic circuit, and VTVM. Owing to use of new inherently logarithmic material, meter is overload-proof and has scale completely linear in db. Use of electrically-suppressed zero enables spreading scale to 20 db. Meter speed same as that of standard VU meter. Frequency response conforms to NAB standard noise test characteristic.—*Audio Instrument Co.*, 1947 *Broadway, New York 23, N.Y.*



Mention No. 973 when filling out card.

UHF Analyzer

New "UHF Megalyzer" is a modification of maker's "VHF Megalyzer" incorporating a coaxial-type wide-band mixer to obtain an improvement in performance and sensitivity. Frequency band is now 30 to 500 Mc. to specifications mentioned below. (To slightly less rigid specifications, instrument can be used to 1000 Mc.). Sensitivity is such

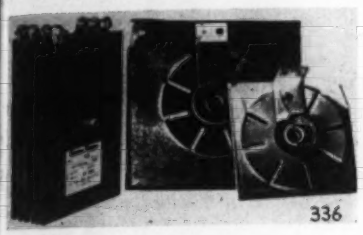


hat signals down to 100 microvolts may e easily seen on 'scope. Equivalent in- t noise is approx. 20 microvolts and requency response is within 4 db. Sig- nals may be studied within a 30 Mc. ange on 'scope at one time. Harmonic electors may be adjusted and r-f. signal evel measured by comparing with out- ut of a standard signal generator. —*Kay Electric Co., Pine Brook, N.J.*

Mention No. 974 when filling out card.

Selenium Rectifiers for Battery Charging

New selenium dry-disk rectifiers for attery-charging applications can be sed for trickle, taper, quick or any ther type of charge; are especially

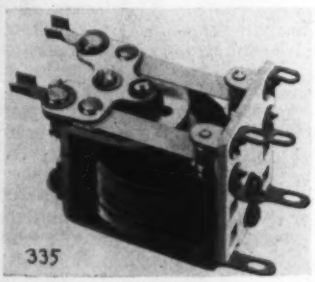


uited for unattended service since there s no possibility of battery discharging n event of a power failure. Individual elenium cell sizes range from 1.25 x .25 in. to 6.25 x 7.25 in. A special pro- ective coating is applied for seashore nstallations or wherever salt spray, igh humidity, tropical climates and orrosive fumes are encountered.—*In- ternational Rectifier Corp.*, 6809 *So. Vic- oria Ave., Los Angeles* 43, *Calif.*

Mention No. 975 when filling out card.

Midget Antenna Relay

New Midget 300-ohm transmit-receive elay has silicone glass material for in- ulation on armature and stationary

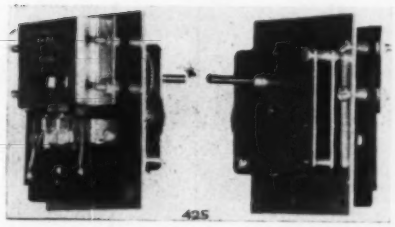


ontact assemblies. Capacity up to 500 watts r-f. (measured on input). A-c. oils available up to 220 volts; d-c. coils p to 110 volts.—*Advance Electric & elay Co.*, 1260 *West 2nd St., Los An- eles* 26, *Calif.*

Mention No. 976 when filling out card.

Instrument Motor

New "Type RSG" d-c. motor is of ermanent-magnet rotor type in which fixed coil supplies magnetic flux to eld structure. Periodic reversal of field ux is attained by means of a single ontactor on rotor shaft. Good starting orque results from eccentric magnetic ap employed and this motor, unlike ost other permanent-magnet types, ill not start in reverse if opposite po- rity is applied. Nominal rotor speed,

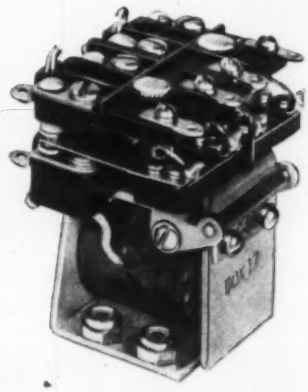


2500 rpm. at rated voltage. Gear re- duction gives nominal 1-rpm. output; other ratios on special order. Voltage, 3 or 6 volts d.c.; others on special order. Current flow at nominal speed is a few milliamperes.—*Brailsford & Co., Inc., Milton Point, Rye, N. Y.*

Mention No. 977 when filling out card.

Power Relay

New "Type DO" power relay is avail- able in contact combinations up to 4- pole, double-throw. Relay terminals and contact arms are mounted on molded phenolic panels. Coil is of cellulose acetate sealed construction. Hence,



maximum resistance to humidity and moisture. Contact rating is nominally 10 amps at 115 volts a.c. non-inductive, or 10 amps at 32 volts d.c. non-induc- tive. Coils are available for continuous duty for operation up to 230 volts a.c. at 60 cycles, or 115 volts d.c.—*American Relay & Controls, Inc.*, 4925 *West Flournoy Street, Chicago* 44, *Illinois.*

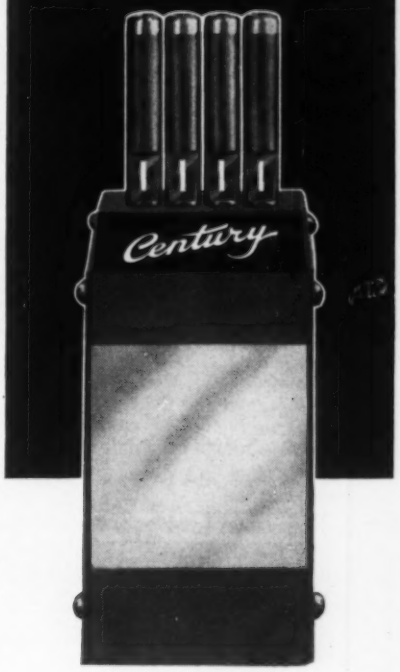
Mention No. 978 when filling out card.

Aircraft Type Relay

New "AN-3352-1" relay is a d-p.-s-t. double-break normally-open 55-ampere type, provided with a new type base- down mounting and inverted terminals for ease and simplicity of installation and wiring. Weight approx. 10.25 oz. Suitable for severe operations from sea

Century

RECORDING GALVANOMETERS



For photographic recording of d.c. or a.c. currents with "flat" frequency response to as high as 2500 cycles per second. Available in a wide range of natural frequencies, all having high factors of sensitivity and dynamic bal- ance. Their tubular hermetically sealed construction insures long-lived depend- ability and ruggedness. Magnetic assem- blies are constructed for 2, 4, 8, 12 and 14 element mounting.

Century also offers a complete repair service on all types and makes of oscillograph galvanometers. Recent ex- pansion of facilities makes possible im- mediate service.

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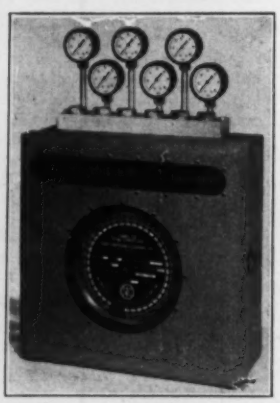

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THE "PUSHBUTTON" CONTROLLER (Illustrated) is our MODEL PB-2. It is a HIGHLY FLEXIBLE example of our many adaptable TIME SEQUENCE devices.

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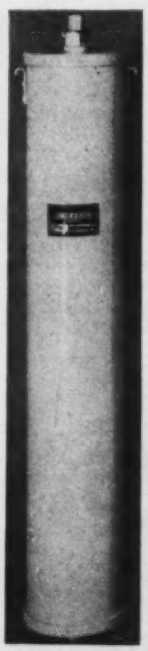

Removes water and oil vapors by cooling. Automatically discharges condensed vapors, filters air through seven layers of finest flannel.

Condensing section contains 68 ft. of ⅜" o.d. copper tubing, providing great heat exchange area.

Condensed vapors are automatically discharged through snap-action, float actuated, valve.

Filter cartridge, made of five concentric, expanded brass baskets, each wrapped with seven layers of canton flannel, furnishes over 15 sq. ft. of filter surface area.

Removal of one 1½" SAE nut dismantles entire filter for cleaning & service.

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level to 50,000 feet through a tempera-ture range of minus 55 C. to plus 70 C. withstands salt spray, sand and dust rated for 10g vibration, 10g acceleration and 25g shock; capable of making motor inrushes up to 600 percent above rated load; approved under Specification AN R-20 b.—*Leach Relay Co.*, 5915 *Avalon Blvd., Los Angeles 3, Calif.*

Mention No. 979 when filling out card.

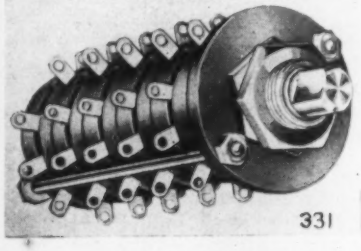
Heavy-duty Soldering Gun

New "Model WD-250" soldering gun capable of handling 250 watts is suited to all commercial and industrial soldering. Five-second dual heat, prefocused spotlight and new "Rigid-tip" are included. Streamlined, lightweight design has terminals in an "over and under" position to give greater accessibility to tight spots and increased visibility with built-in spotlight.—*Weller Mfg. Co.*, 808 *Packer St., Easton, Penna.*

Mention No. 980 when filling out card.

Miniature Multi-deck Tap Switch

New model of "Series 5000 Miniature Tap-Switch" is designed for multi-deck applications. Heretofore available only as a single-pole tap-switch so constructed as to permit up to ten contact positions, unit is now available as a series of poles, or decks, designed for ten or fewer contact positions per deck.



Stops are located in switches of nine positions or fewer per deck to allow rotation through only the correct cycle. When ten positions are necessary, stops are eliminated to give continuous rotation in both clockwise and counter-clockwise directions. Switch is rated to break 1 ampere at 115 volts a.c. When not required to make or break the circuit it will carry up to 5 amperes at 115 volts a.c. Contact arrangement: make - before - break or break - before-make.—*Grayhill*, 4524 *W. Madison St., Chicago* 24, *Illinois.*

Mention No. 981 when filling out card.

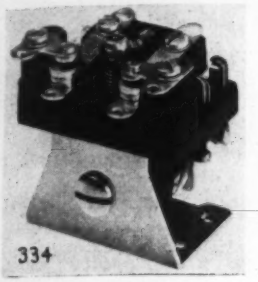
Sealed-plunger Snap-acting Switch

New "Unimax Model KMXN-2A" precision switch is protected against moisture, dust, and oil in plunger mechanism by a neoprene "boot" sealed to actuating plunger. Sealed-actuator assembly is integral with metal case. Neoprene compound, besides being oil-resistant, retains its flexibility at all temperatures from minus 65 F. to plus 160 F. Basic switch slips onto positioning studs inside the metal "Adapta-case," may be withdrawn for convenient connection of wiring after housing is fixed in position.—*Unimax Switch Div., W. L. Maxson Corp.*, 460 *W. 34th St., New York* 1, *N.Y.*

Mention No. 982 when filling out card.

General-purpose Relay

New general-purpose relay has electrical connections well spaced for easy accessibility; molded Bakelite insulation, armature and frame designed for perfect operation under extreme vibration and shock conditions; metal parts heavily plated with cadmium or nickel. Universal-wound coil is vacuum varnish



impregnated. Six contact combinations available up to d-p. d-t. Contacts on standard units 0.25-in. diameter pure silver, rated 115 volts a.c. or 24 volts d.c. non-inductive; any operating voltage up to 300 d.c. or 440 a.c.; special alloys for higher loads. Small size makes new relay suitable for all types of plug-in or hermetically-sealed requirements; can be built to AN specifications.—*Advance Electric & Relay Co.*, 1260 *West 2nd St., Los Angeles 26, Calif.*

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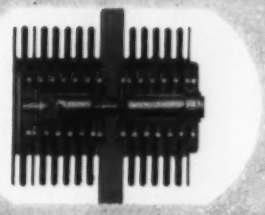

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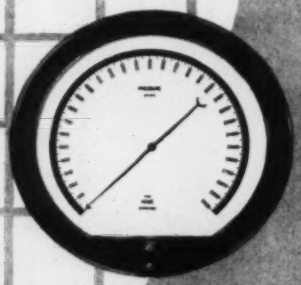

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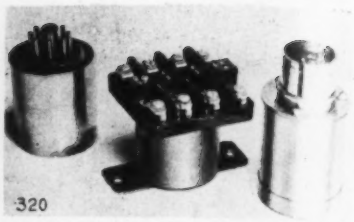

harmonic) of 0-55 cycles at 0.060 inch total excursion. Available in hermetically-sealed or dust-tight assemblies for extreme temperature and altitude conditions.—*Dep't. "C", Electrical Products Corp., 1100 North Main Street, Los Angeles 12, Calif.*

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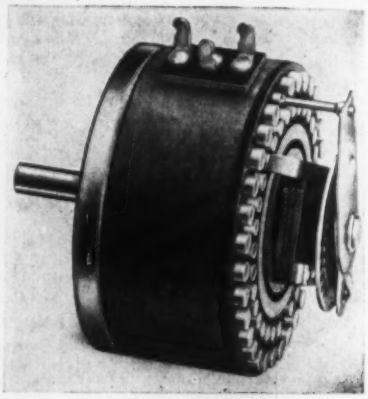

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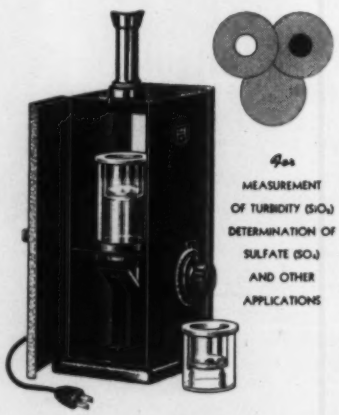

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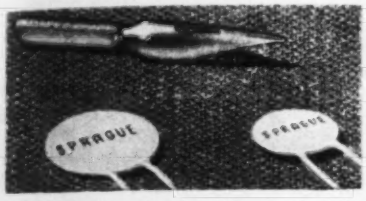

directional leads are soldered to silvering; capacitors are coated with a tough moisture-resistant insulating resin, fit neatly across miniature tube sockets, are extremely efficient as high-frequency bypass capacitors; have a high insulation resistance and are also useful as coupling capacitors in low frequency circuits.—*Sprague Electric Co., North Adams, Mass.*

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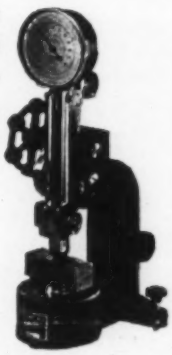

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Application Factors in pH Control

Continued from page 806

of simple construction (Fig. 51) are quite satisfactory for continuous recording installations. The method has not been wholly satisfactory on critical control installations because of transfer lags introduced by a deaerator which is necessary to separate air from the sample. In some cases it has been possible to use submersible electrode assemblies of standard construction, or special assemblies fabricated from corrosion-resistant materials; but, as a general rule, it is more desirable from a maintenance point of view to remove the electrodes entirely from the tank vapors. The important criterion of such processes which affects equipment selection is maintenance requirements, and it usually is more advisable, and a cheaper long-term investment, to use sampling pumps of special alloys or other corrosion-resistant materials to transfer the test sample to an outboard flow assembly. Not only do the tank vapors introduce a serious corrosion limitation but, if the process is operated at fluctuating or above ambient temperature, the connecting conduit to the electrode assembly will "breathe," with resultant accumulation of moisture over the electrode terminal connections and grounding of the measuring circuit. It cannot be overemphasized that suitable sampling pumps and outboard flow assemblies, although more costly in initial outlay, are more trouble-free, especially on critical automatic control installations. It must be remembered, too, that transfer lags must be kept below a practical limit and the connecting piping and sampling pump must be sized in keeping with these requirements. Having a given transfer distance from tank to electrodes, one may determine the appropriate pipe size and pump capacity by reference to Fig. 45. Sampling lags in necessarily long runs of connecting piping may be minimized by the method described in connection with Fig. 44.

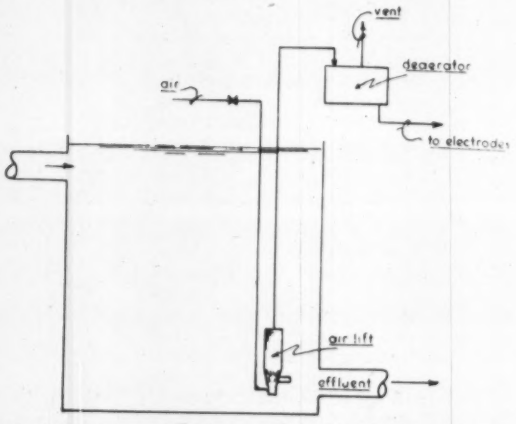

Fig. 51. Air lifts are sometimes used to withdraw electrode samples of corrosive fluids.

* * *

An important instrumentation problem in the paper pulp industry is that of regulating or measuring pH of bleach stock. The stock may vary in consistency from 2 to 4 percent upwards to 17 percent, depending on the process. The 17 percent stock is so heavy in consistency that no loose water is visibly present; it looks like moist cotton. It is necessary to extract continuously a liquid sample of bleach liquor from the pulp for pH measurement in an outboard flow assembly. It is not possible in many cases or desirable, in most such applications, to use a submersible electrode assembly because of excessive electrode maintenance and sometimes breakage.

It is not easy to separate the pulp and liquor continuously because of the tendency of pulp fibres to form a mat over the screening surface if a large pressure drop exists across the screen: it is necessary, therefore, to use special precautions to avoid the effect of pressure drop across the sampling device.

Fig. 52 is an illustration of a continuous pulp sampler which the writer has developed and used successfully. It

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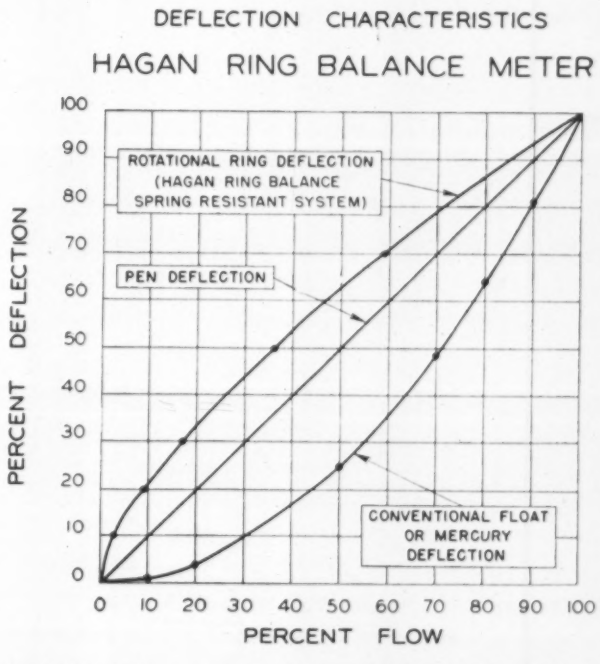

Graph shows how compensating mechanism of Ring Balance meters reduces movement of pressure responsive element, while in conventional meters this must be magnified to produce a linear flow chart.

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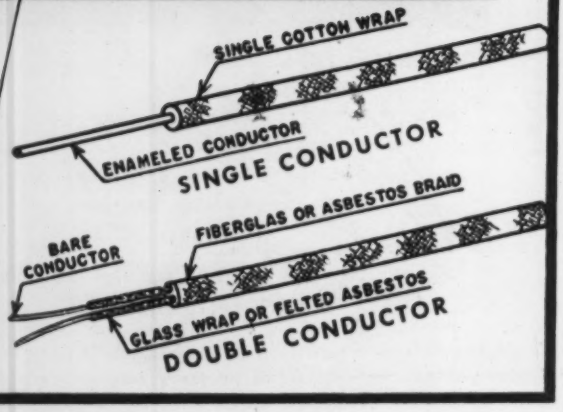

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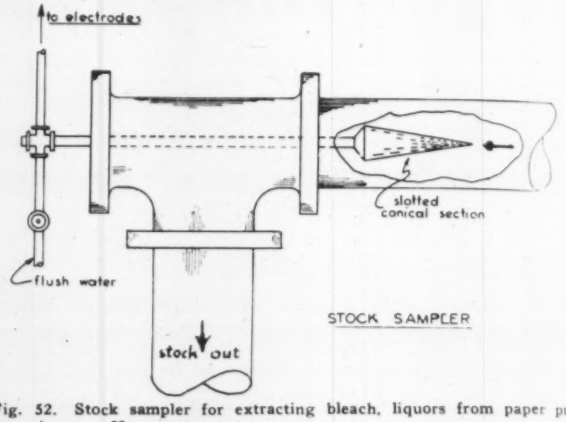

Fig. 52. Stock sampler for extracting bleach, liquors from paper pulp for continuous pH measurement.

This sampler has been used satisfactorily on pulp up to 4.5 percent consistency. A water connection is provided for back washing the screen.

* * *

Another continuous sampler which has been used successfully by the writer is illustrated in Fig. 53. It consists of a Venturi section perforated with 1/64-inch holes near the throat. A concentric jacket collects the filtered sample for delivery to the electrode assembly located at sufficient hydrostatic elevation above. This sampler is likewise equipped with a back-flush water line: It has been used on 8 percent stock.

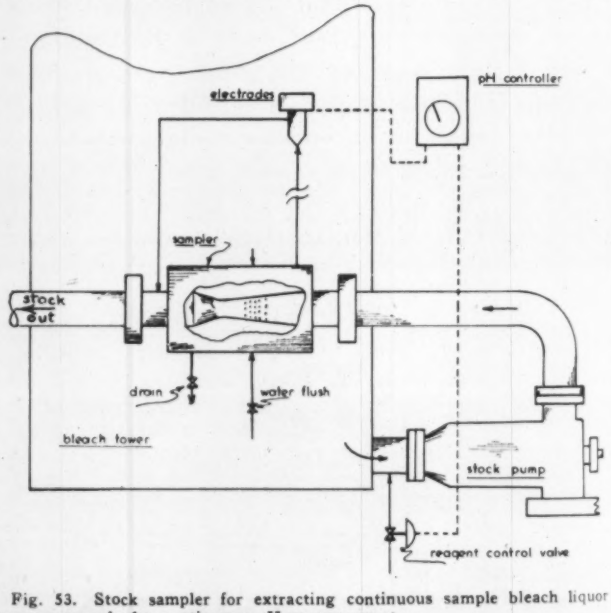

Fig. 53. Stock sampler for extracting continuous sample bleach liquor from paper pulp for continuous pH measurement.

* * *

Low-density bleaching is sometimes carried out in Belmer type bleachers, not unlike a conventional pulp beater:

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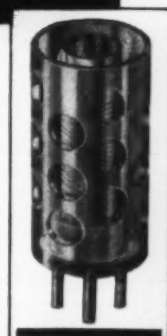

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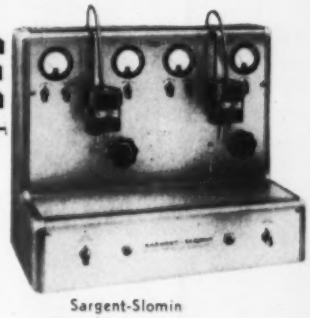

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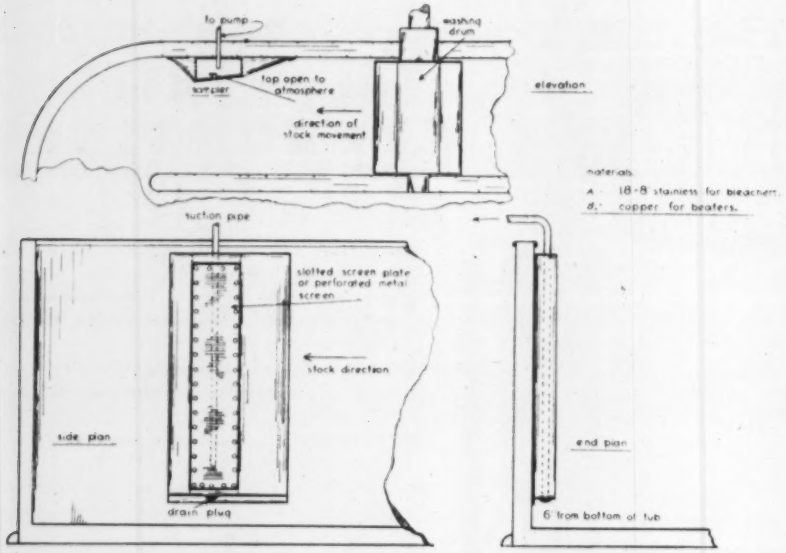

Fig. 54. Stock sampler for extracting continuous sample of bleach liquor from low density paper pulp for continuous pH measurement.

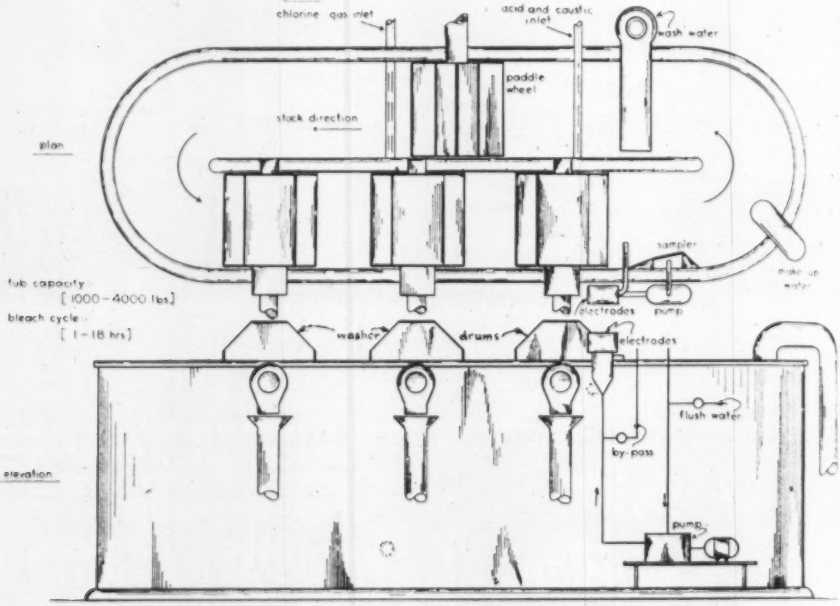

Fig. 54-A. Full view of application of pulp sampler illustrated in Fig. 54.

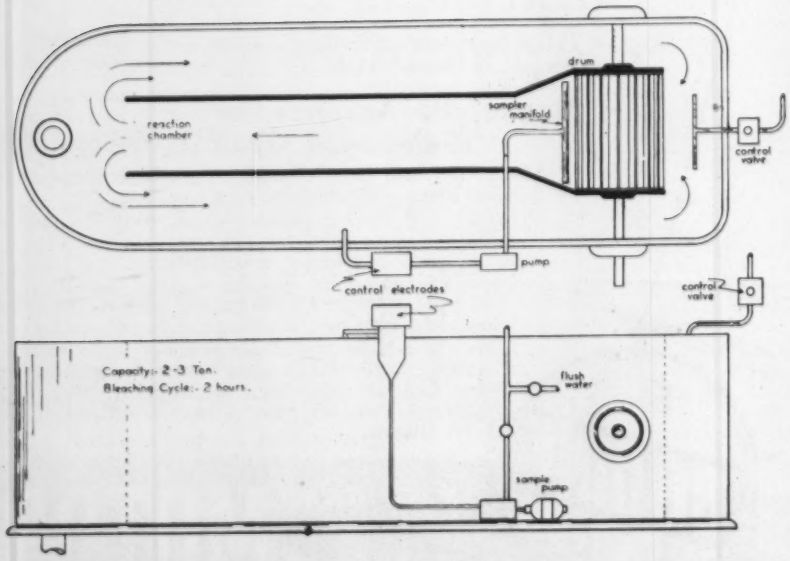

Fig. 54-B. Showing application of full automatic control to low-density special pulp bleacher not requiring electrode sampling device.

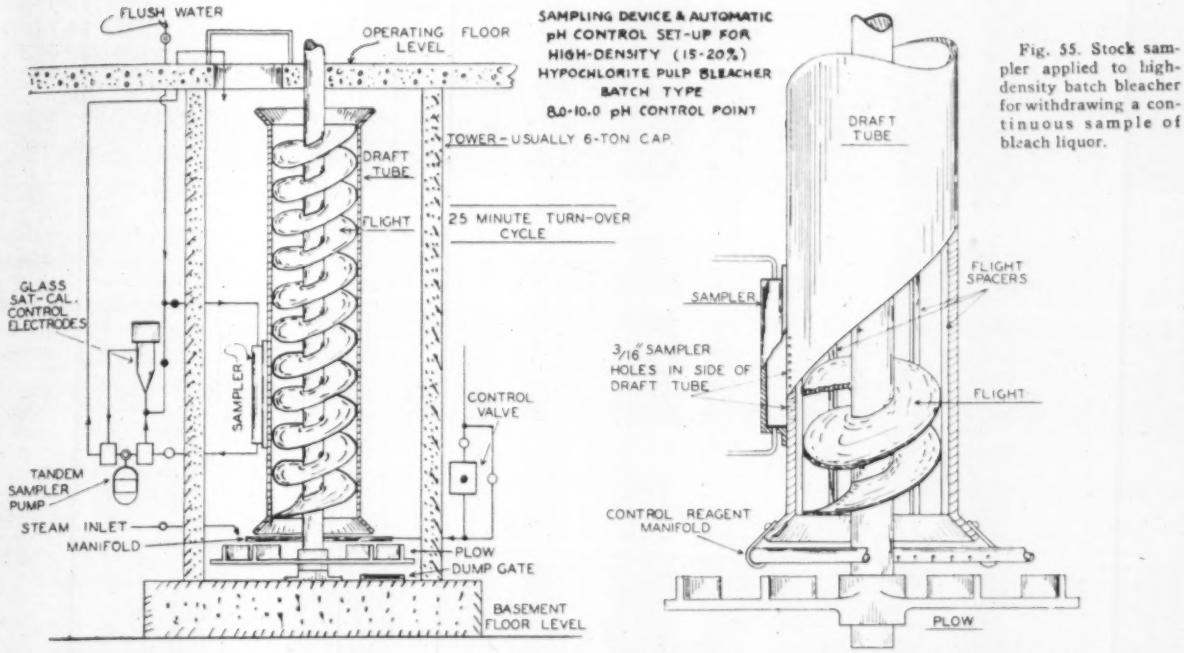

Fig. 55. Stock sampler applied to high-density batch bleacher for withdrawing a continuous sample of bleach liquor.

The pulp is circulated by means of a power driven paddle wheel. Consistency of the pulp is usually 4 percent or below.

Should one carefully observe the action of the circulating pulp, it may be noticed that a lateral force exists near the end of the Belmer where the pulp mass shears against the curved wall and reverses its direction of flow. The squeezing action of this force causes a partial separation of liquor and pulp near the wall. By taking advantage of this effect, the writer has successfully developed and applied a sampler requiring little if any maintenance. It consists of a wedge-shaped box open at the top and mounted in the Belmer as shown in Fig. 54. The shearing surface is a section of a slotted plate from a flat pulp screen. The sampler is installed in the Belmer near the end where lateral forces separate the pulp and liquor. A centrifugal pump is throttled to withdraw filtered liquor from the box at a rate sufficient to not exceed a head difference of more than 2 inches between liquor level inside and pulp level outside. Shearing action of flowing pulp prevents formation of a mat over the screen.

* * *

The problem of measuring pH continuously in a high-density (17 percent) bleacher is probably the most difficult sampling problem the control engineer will find in bleachery applications. The pulp has all liquid absorbed within the pulp mass and a squeezing or wringing action is required to release it: Fig. 55 represents a typical application to a high-density batch bleacher. The tower is charged with unbleached stock which is circulated upwards by means of a "flight" (screw conveyor) in a central draft tube and a bottom plow, which gathers the pulp and plows it toward the flight.

It was not possible to extract a sample from the top of the draft tube, but two conditions made it possible to withdraw a sample of liquor near the bottom. First, the heavy mass of pulp above causes partial separation of pulp and liquor below and, secondly, the squeegee action of the flight on the pulp at the inner wall of the draft tube made it possibe to withdraw a continuous sample. The wall of the draft tube was drilled with 3/64-inch holes in a rectangular pattern 2 inches by 8 inches. A collector, made from a longitudinally-halved section of 3-inch brass pipe welded to a flange and having closed ends, was bolted to the side of the draft tube over the holes. A pump delivered the filtered sample to the electrodes installed on the operating floor.

It is sometimes necessary to measure pH of the aqueous phase of an emulsion or mixture of water solution and immiscible organic liquid. For example, in the petroleum refining industry, anhydrous ammonia is injected into distillate streams to prevent corrosion of condenser tubes by organic acids present in the distillate. A measurement of pH of the decanted aqueous effluent from the condenser is sometimes used as a guide to manual regulation of ammonia feed. However, the electrode may become insensitive at times because of a coating of oil which passes the decanter.

Similar applications are found throughout the chemical industry. In one such process requiring pH control of an aqueous suspension of light, oily immiscible organic liquids, the electrodes fouled and became insensitive after brief exposure. Decanters were ineffective in completely separating the two phases but a selective filter which had been developed by the writer for previous experimental investigations was installed and has operated continuously without unusual electrode maintenance since its installation.

The selective filter, illustrated in Fig. 56, consists of two ceramic thimbles which have had separate treatment with selective surface active agents. The surface-active agent of one thimble is selectively "wetted" by water and passes the aqueous phase but rejects the hydrocarbon phase; the other thimble is treated with another surface active agent which "wets" by the hydrocarbon but rejects the water layer. The water layer is passed to the electrodes while the organic phase returns to the process.

Thimbles of this type are available commercially for separation of various liquids and may be applicable to other pH problems or similar instrument applications.

* * *

One novel application of pH has been in the continuous measurement of "acid character" of clays, sands and slags. The pH of blast furnace slags indicates whether the charge

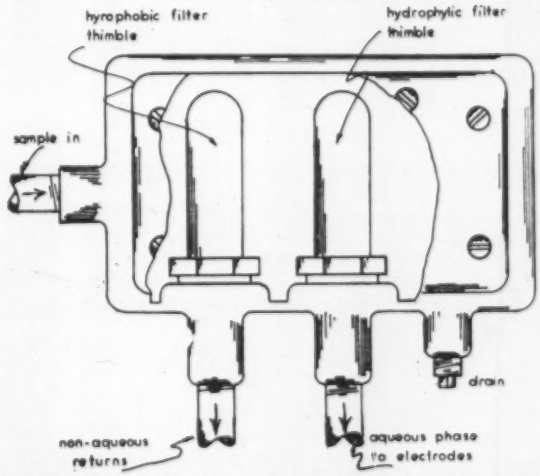

Fig. 56. Selective filter for separating hydrocarbon immiscibles from aqueous electrode sampler.

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was acid or alkaline, which has bearing on smelting practices and life of the refractory lining; while pH of clay and casting sands has bearing on ceramic quality and surface condition of metal castings respectively. While these are largely laboratory measurements taken at periodic intervals, there is an important industrial application of regenerative sands having selective absorptive properties: the pH of some of these sands is a measure of saturation absorption. However, it being a dry sand, the presence of water is required for conventional pH measurements. Usually, the process is a reversal type, but a continuous purge of water through the bed is an effective way of sampling the test material, which, with a measurement of pH difference across the bed, as indicated in Fig. 57, provides

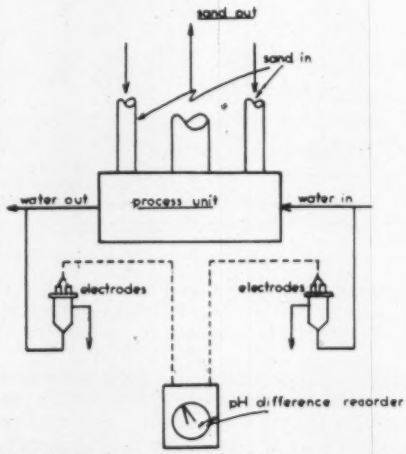

Fig. 57. pH difference measurement of regenerating water reveals activity of processing sands.

measurement of activity of the sand. Or, if the sand is used to process a liquid stream, a single pH measurement of the effluent is customary practice.

* * *

Some few applications require continuous pH measurements under partial vacuum or at elevated pressures. If the pressure is much above atmospheric, it is customary to bleed off a continuous sample of liquor and measure pH at atmosheric pressure. The reduction in pressure has a tendency to change pH but this is not serious in most industrial applications. Special electrodes have been built and successfully operated at extremely high pressures; and a model glass electrode developed by the writer has operated satisfactorily at 150 psi. and has been tested at much higher pressures. Metal-metal-oxide electrodes have also been operated experimentally at high pressures.

There is little published data on the pressure limitations of glass electrodes but the usual source of trouble in common industrial applications is the calomel half-cell. Very large pressure differences across the junction bridge sometimes cause segregation or reverse flow and resultant polarization errors. This has been overcome in the writer's practice by back-connecting both the glass and calomel electrodes to equalize pressure on both sides of the glass membrane and calomel junction. This arrangement has operated successfully at 150 psi. under experimental laboratory conditions and has operated continuously on an industrial process maintained at 27-inch Hg vacuum.

* * *

The inventory or liquid hold-up of conventional electrode assemblies is relatively large for certain small-scale pilot plant operations. The lag introduced by this hold-up is large with respect to reaction time and inventory of the process and it is desirable to divert smaller volume samples to the electrodes. At least one manufacturer offers micro-electrodes and assemblies while another offers the MacInnes type electrode for such applications. The McInnes electrode consists of a small tubular section of pH-sensitive glass through which the test sample flows. This section is jacketed with non-pH glass containing an appropriate internal reference

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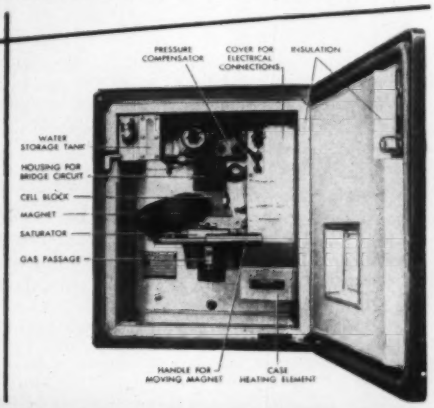

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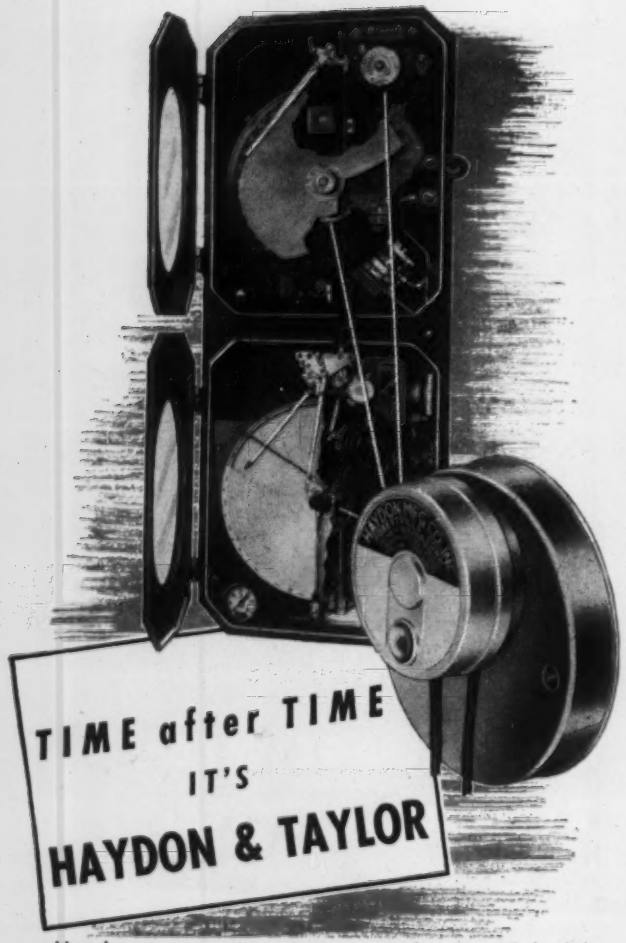

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* * *

The glass electrode is a high-resistance devi[illegible] and usually is connected to the recorder or amplifier wi[illegible] shield ed cables which are run through conduit. Leakage r[illegible]stanc to ground of the cable must be kept high, prefera[illegible]y 100 times electrode resistance; and precautions are re[illegible]red t assure this condition. The cable must not be k[illegible]ked stressed in tension, and must be run through co[illegible]tinuo conduit which terminates electrically in a continu[illegible]s bon between the assembly and recorder case. A continu[illegible]s ele trical bond is necessary to avoid electrostatic pick[illegible]up ar disturbance from radio-frequency sources. The cond[illegible]t mus be grounded electrically; it should not be run through high temperature regions; and precautions are sometimes re quired to avoid "breathing" and accumulation of moistur inside. If the conduit runs from a hot moist atmosphere int a cold region, there is danger of collecting moisture inside and grounding the lead wires. In such cases, down loop should be avoided or otherwise provided with a drip leg. Under extreme conditions of "breathing" it has been found necessary and desirable to purge the conduit continuously with air from the recorder or amplifier case outwards.

The maximum permissible length of lead wire is usually limited by either of two factors, individually discussed in the following:

(1) *Capacitance per foot of the high-resistance shielded cable connecting the glass electrode and recorder or amplifier.*

The effect of this capacitance is to alter the time constant of the measuring circuit and limit speed of response of the instrument to changes in pH of the solution measured. Some cables may have a comparatively low capacitance of 6.0 or 7.0 $\mu\mu$f per foot length while others, more commonly used, may approach 100 $\mu\mu$f per foot. Bearing in mind that the glass electrode resistance may average 100 megohms under normal conditions, the use of a "high capacitance" cable would introduce a delay or *RC* time-constant into the measurement of 0.01 second per foot of lead wire, which corresponds to a one-second delay in response to changes at the electrodes if located a distance of 100 feet from the recorder. Other cables of lower capacitance, though much more costly, may reduce the time constant to 0.001 second per foot; still others, of the "lo-loss" co-axial type, may introduce a delay of only 0.0001 second per foot, but at a cost increment of 10 or more.

Moreover, the resistance of the glass electrode is not constant but varies with temperature, and may even reach a resistance of 1000 megohms at low temperatures of the solution measured. Each multiple of ten change in resistance of the electrode increases the time-constant, and hence the time of response, by a factor of ten. It is apparent, therefore, that the maximum permissible length of lead wire is not only a function of lead wire capacitance but also the resistance of the electrodes, which, in turn depends upon their operating temperature. Some glass electrodes have been developed having extremely low resistance (comparatively) and are especially well favored for low temperature operation; they have made possible an extension of maximum cable lengths for critical control installations. In any event, before the control engineer can safely recommend a given installation of pH control equipment, he must know the capacitance per foot of cables used, the resistance-temperature characteristics of the electrode system and the operating temperature of the process. Knowing this, he can readily determine whether the corresponding time constant will seriously affect the response of the equipment to changes in pH of the process being controlled.

Not only is the *RC* factor important in automatic control installations but it also has bearing on the accuracy of a multiple point pH recorder. It also limits the maximum spread in pH difference of the points measured by a multi-point recorder since it limits the minimum time for "balancing in" on each point. High resistance electrodes and/or high capacitance cables may limit the spread between points to 3.0 pH or below for balancing-in accuracies of 0.1 pH at 30 seconds per point. The larger the spread between points the larger is the delay charge which accumulates in the lead wire capacitance, and the greater is the time required for balancing-in on each point. The usual glass electrodes, having resistances of 100 to 500 megohms or above, may require at least one minute per point for accuracies of 1 percent, depending upon the sensitivity of the input measuring circuit.

High-speed pH recorders, which balance-in at a few seconds per point or scan the scale within a few seconds or fractions of a second, may offer no practical advantage if they operate in a high-*RC* electrode-lead wire combination. Much experimental work has been done to decrease the resistance of glass electrodes, but, until this is accomplished, and the electrodes are used in conjunction with a suitable length of lead wire of appropriate capacitance, there may be little to gain in using high-speed recorders, particularly on low-temperature applications.

(2) *Losses and d-c. resistance-to-ground of shielded conductor.*

Body resistance and conductor-to-shield current losses of the insulating core shunts the electrode resistance and "shorts" the input circuit with a resultant error in instrument calibration, the seriousness of which depends upon the length of cable. This factor is not so important with modern equipment since the losses per foot of good shielded cable are very low and can be ignored within the length limits set by the capacitance and *RC* factor. It has been experienced, however, that insulation resistance of the shielded conductor is affected by high temperature, and some few cables which had been run in conduits adjacent to exposed steam lines

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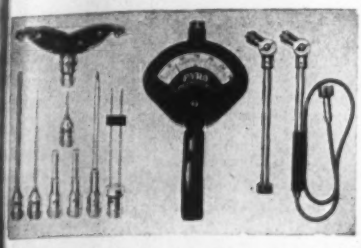

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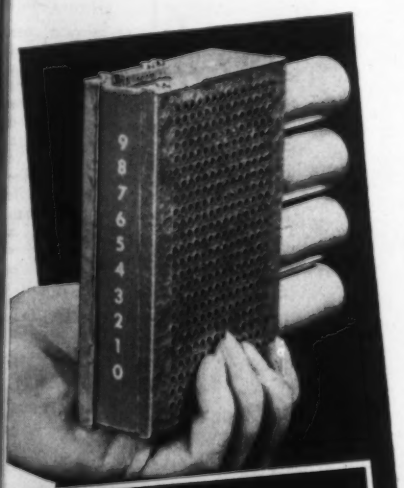

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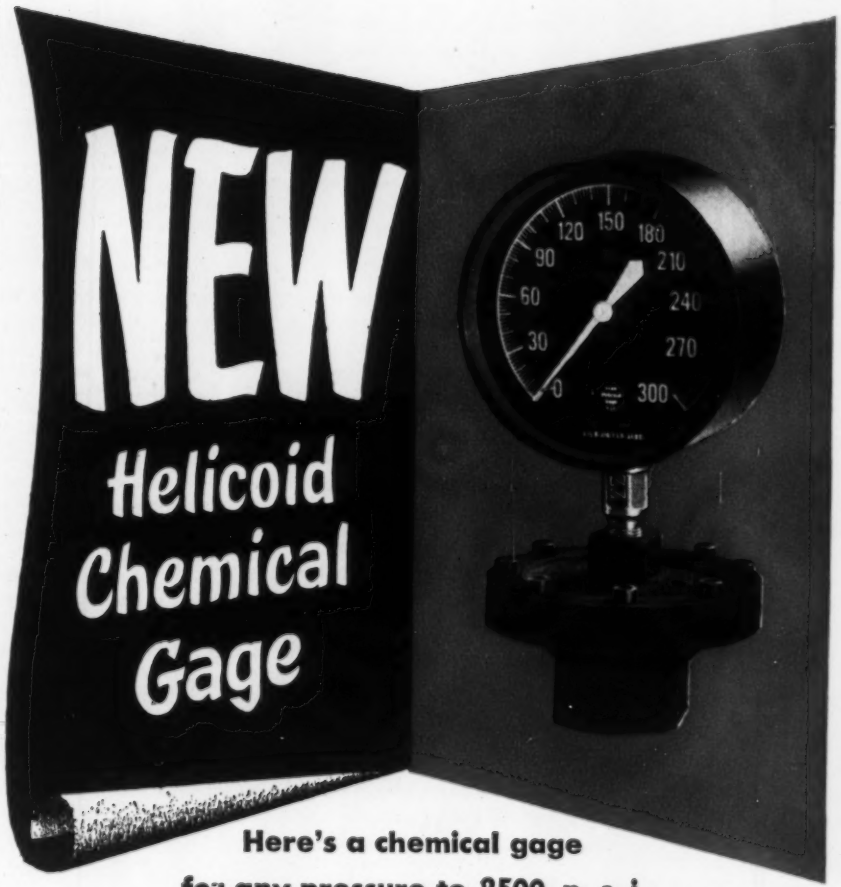

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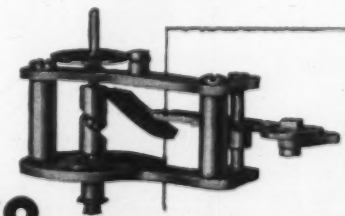

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(maximum cable length, 30 to 50 ft.) increased their cond... ground with a resultant error of 3.0 to 4.0 pH within a few w...

This leakage factor is also important at junctions or spli... cable; it is doubly important in high-humidity applications. T... ing core of some cables is rubber or "substitute rubber," wh... comparatively easily with water and forms a conducting path... surface when the outer protective sheath is cut away for splic... more expensive cables, having insulation cores of polyethylene... rubber," have extremely high body resistance, and do not "... with water, and the core can be exposed at splices without any ... losses due to surface leakage at humidities limited only by act... sation. Cables having soft rubber cores may be satisfactory fo... stallations, but their body conductance is usually higher than p... cables, and they are recorded only for short runs. It is necessa... protect the exposed ends of soft rubber cables at splices or ... with polystyrene cement or thimbles which have low surface "...

It is of interest to note that solid-wire shielded conductors u... lower capacitance-to-shield than stranded-wire conductors of ... gage for a given core material, and ordinarily can be used ... lengths than stranded-conductors for a given limiting *RC* time-constant... Its "break-in-tension" strength is less, but this is not an ... factor if the cable is handled properly in transit and installation, since it ... not subjected to flexing in use. No. 20 gage conductor has been fou... satisfactory for industrial installations. Its "break-in-tension" streng... is approximately 50 pounds which is quite ample if the proper techniq... is used during installation. It is not advisable to use larger conducto... because of their higher capacitance; smaller conductors are more vulne... able to handling by plant mechanics and the wire may cut through t... insulating core and short against the shield when the cable is being pull... through conduit turns or junction boxes.

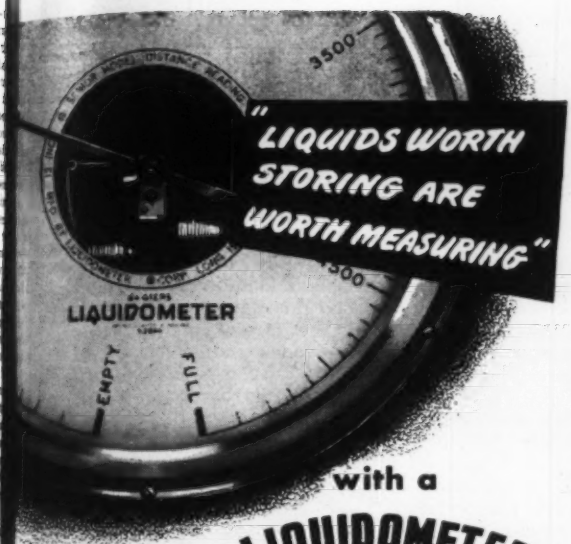
Leakage currents to ground occur most frequently not a... a result of bad instrument design but because of improp... installation technique, which, in turn, is a limitation co... fronting the equipment manufacturer. Plant electrician... are usually unaccustomed to handling anything but relative... ly heavy low-resistance power equipment and wiring whe... a ground resistance test of a few megohms is an "open ci... cuit." They do not realize that the same resistance-to-groun... test in high-resistance instruments is a "dead short." Cable... usually received from the vendor in a loose roll, are not i... frequently laid flat on the floor and "pulled from the center... with resultant "stress loops" or kinks at each roll. Or, th... cable may be completely unrolled and stretched out its fu... length to relieve stresses prior to pulling, in which case it i... sometimes stepped upon and the conductor breaks or cut... through the insulating core because of high pulling tension... caused by dragging friction of the cable on the ground. Pul... ing soaps have frequenty caused leakage breakdown, par... ticularly at splices or near terminal connections. Soaps hav... been observed to "creep," especially in hot humid plant at... mosphere, and ground or short the terminal or splice con... nections; or, as observed in some cases, they have effecte... decomposition of the insulating core within a year's time... In one instance of a bleachery installation where chlorin... atmosphere is usually high, the pulling soap had "crept" ... distance of fifteen feet between the conductor and insulatin... core and the chlorine had almost completely corroded th... stranded conductors over the full length of "creepage."

The writer has recommended talcum or similar powder... as pulling lubricants, and has found lycopodium particularly... satisfactory. Not only does lycopodium lubricate but it repel... moisture films and has been especially beneficial when duste... over splice or terminal connections. In fact, many installa... tions infected with moisture grounding at the electrod... assembly terminal connections have been completely cure... merely by dusting the terminal block with lycopodium... powder.

It is more generally the rule than the exception tha... hinges and hold-down screws of terminal box or assembl... cover plates corrode beyond use within a few weeks time. A... a result they are either left open entirely or closed loosely... with the attending collection of moisture and grounding o... terminal connections.

Corrosion is not wholly an operating problem but is mor... directly a design limitation and should be recognized an... treated as such by equipment manufacturers. Corrosion-re... sistance in use, especially in the chemical manufacturing in... dustry, is no less important than performance characteristic... In many cases it is more important, and he is a wise equip... ment manufacturer who recognizes this and other use lim... tations and designs equipment accordingly.

Cable failures could be minimized if each individua... length were supplied on a spool and unrolled from a spindl... and powdered as pulled. Furthermore the writer has foun... it preferred practice to pull reference electrode and shielde...



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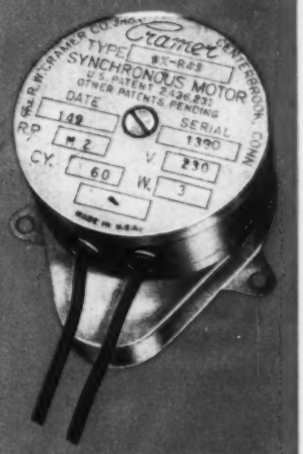

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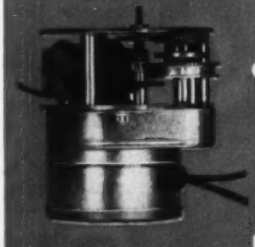

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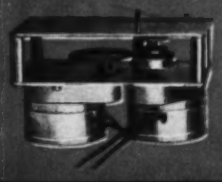

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conductors simultaneously and tape them together at fi foot intervals. The reference electrode cable is usually N 14 RW and serves as reinforcement for the more vulnerabl shielded conductor. Only one pair of conductors for a sing electrode assembly should be run through a 1-inch conduit and only two pairs through a 1½-inch conduit. Pull box should be installed at 50-ft. intervals in relatively straight runs or at 25-ft. intervals in meandering runs. A loose d of cable in a pull box serves as an expansion loop and relieves tension or loop stresses in the cable.

Many industrial installations of pH equipment are operating with lead wire lengths of 100 to 200 feet. Whether the length can be exceeded or equaled for multi-point recorder or critical control installations depends largely upon: (a) increased sensitivity of the measuring circuit, and (b) lower-resistance glass electrodes and low-capacity shielded cables. It is not advisable to use excessive recorder sensitivities which may expose the instrument to instability and minor line disturbances; but, on the other hand, it has been possible to take advantage of high input sensitivities by using a preamplifier located near the electrode assembly which, in turn, is connected to a remote recorder through a low-resistance circuit. It is generally advisable to keep the *RC* factor as low as possible, commensurate with accuracy requirements and the "activity" of pH variations in the process. If either of these conditions is high, the recorder should be located within 25 feet of the electrodes, or, if this does not conform with control house requirements, a preamplifier should be located as near the electrodes as possible (within practical limitations) and connected to the remote recorder in the control house through a low-resistance circuit. It is furthermore desirable, from the standpoint of *RC* delays in multi-point recorder installations, to use individual preamplifiers at each electrode point and commutate the low-resistance output circuit of these units with a single remotely-located multi-point recording millivoltmeter. The disadvantage of this system is its cost which may over-ride its gain in accuracy over a single multi-point pH recorder which commutates the high-resistance circuit of each electrode point. Should the accuracy and "spread between points" limitations of the latter equipment be satisfactory for a given application, it probably can be had at a lower cost. If highest accuracy is required, and the spread between points exceeds the limits of the less costly equipment, it may be necessary to use the preamplifier combination.

Buffer index of the process also limits permissible length of lead wire in the high-resistance glass-electrode circuit. Processes having a buffer index of 3.0 or above are usually subject to unusual "activity" of pH changes unless loads are stabilized and the controller operates in an extremely high residence system. If pH changes are "active," it usually will be found advisable not to exceed a lead wire length of 30 to 50 feet for a single-point recorder or recorder-controller installation. On the other hand, if minimum error from the *RC* source is desired, it may be preferable to use equipment of the preamplifier type which can be purchased for little, if any, price differential. What's more, the preamplifier equipment favors the use of high-speed millivoltmeter recorder-controllers operating in the low-resistance output circuit since response limitations of the over-all equipment can be minimized by using short-connected lead wires to the electrodes.

It is highly important, with most industrial pH measuring equipment, that the lead wires be run in metal conduit which is grounded electrically and forms a continuous electrical bond between the recorder or preamplifier and electrode assembly. Although the glass electrode conductor is electrically shielded, this shielding is not sufficient to prevent electrostatic pick-up, especially in the vicinity of arcing d-c. machinery or other sources of radio frequencies. If exposed, the cable may behave as an antenna and pick up stray atmospheric voltages which appear on the chart as sharp excursions of the pen. A conduit behaves as an electrostatic guard circuit and nullifies the effect of these stray voltages.

It is also desirable to run all power leads through conduit which is isolated from the measuring circuit, and, furthermore, it is advisable to not operate the pH measuring equipment from a common power circuit which supplies heavy ma

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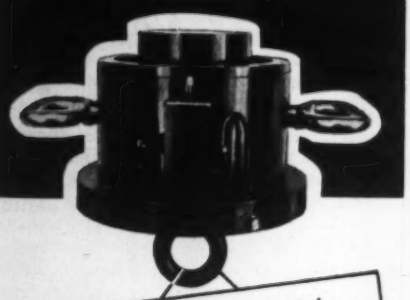

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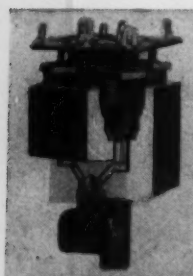

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chinery or intermittent-arcing, or load-fluctuating equipment. These load or arcing surges may become manifest as r-f. feedback which finds its way through the power circuit to the measuring circuit of the instrument with resultant instability. Conduit is particularly necessary when the pH recorder *must* be operated near intermittent machinery. The writer has observed, in this respect, that a completely "conduit shielded" power circuit was effective in completely damping out the surge of a 50-ampere arc and materially damping the surge of a 100-ampere arc taken off the line at a point just 3 feet away from the recorder outlet, whereas without the conduit, the same arc caused periodic pen excursions of 2.0 to 3.0 pH.

Input sensitivity and grid current of the measuring circuit are important limitations to measurement accuracies. Bearing in mind that glass electrode resistance varies from 50 to 500 megohms and that a unit change in pH corresponds roughly to 59.7 millivolts (at room temperature), a 0.1 pH change demands a current sensitivity of 12 micromicroamperes or less. On the other hand, should grid currents reach the extreme value of one microampere, the resultant voltage drop in a 1-megohm electrode system is 1.0 volt which, at 60 millivolts per pH, corresponds to an error of 16 pH, or more than the entire scale. This analogy is only relative but is presented to stress the importance of grid current and input sensitivity to accuracy of measurement.

Grid currents rarely exceed 10^{-10} ampere for conventional industrial equipment or 10^{-12} to 10^{-14} ampere for special-purpose instruments; and precautions are necessary to maintain these and other circuit design constants during operation. Tubes with glass envelopes and top grid connections are preferred and insulating materials of high body and surface resistance, i.e., polyethylene etc., are required. Glass envelopes of input tubes must be free of grease films (fingerprints, etc.) and are usually coated partly with polyethyene or silicone cement to avoid stray leakage currents across the glass surface.

Capacitors having low-loss dielectrics and high body resistance; and grid resistors and other input circuit components having the same characteristics, are preferred. It is further desirable to coat all components of the critical input stage with polyethylene or similar cement and use rigid wiring with a minimum of anchor points.

Pure resistance joints of a few ohms are inconsequential in the input circuit but it is usually observed that "bad joints" are corroded joints which develop galvanic potentials and introduce a pH error proportional to the corrosion potential. Maintenance personnel sometimes use acid solder flux or more frequently use a paste flux which is "non-corrosive" in a low-resistance sense of the word. It is important that corrosion currents be avoided. They are not serious in most low-resistance power wiring but the potential drops introduced into high-resistance instrument circuits constitute a major source of error and it has been found desirable to use only a flux similar to pure rosin in ethyl alcohol.

* * *

High-temperature applications (above 70 C) have been particularly troublesome in the writer's experience; not so much a fault of the glass electrode as the calomel half-cell. The junction bridge of this electrode has been subject to polarization errors at high temperature which could only be eliminated by maintaining a continuous and relatively high rate positive flow of KCl through the junction. This condition of polarization becomes manifest as sluggish and inaccurate response of the recorder. It has been observed that certain calomel electrodes, in which the platinum collector wire dips directly into the mercury in contact with saturated KCl, are affected by corrosion or apparent amalgamation of the platinum wire at the point of interface between mercury and KCl solution. It has also been observed that, in many such electrodes operating at high temperature, the calomel reference potential drifted upwards, apparently caused by catalytic oxidation of calomel to mercuric chloride. It has not been uncommon experience, particularly with low-resistance electrode systems operating under slight polarizing currents, at low recorder insensitivity, to find the gray or white calomel paste completely dissolved after a few days' operation at elevated temperatures.

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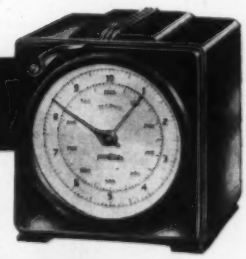

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S-6	1/1000 min.	10 min.	±.0002 min.
S-1	1/100 sec.	60 sec.	±.01 sec.
MST	1/1000 sec.	.360 sec.	±.001 sec.
MST-500	1/1000 sec.	30 sec.	±.002 sec.

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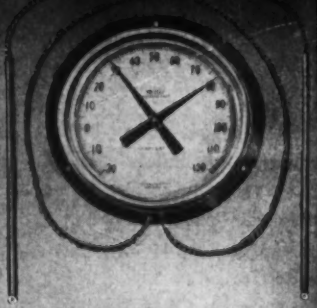

Duplex, mercury actuated, plain bulb type indicates temperatures at two separate points.

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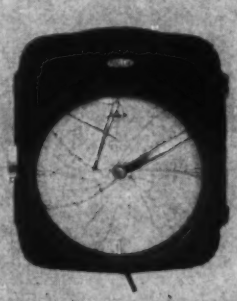

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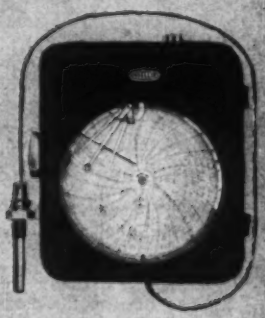

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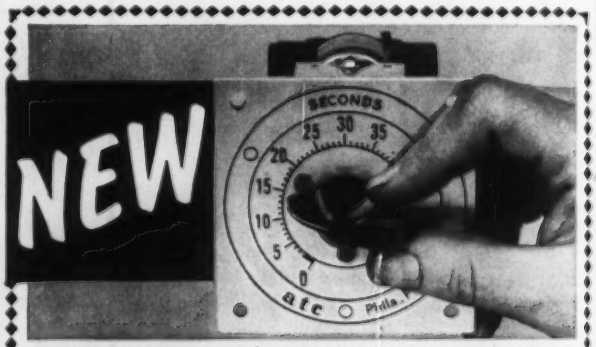
ting ground-glass sleeves or plugs have not been wholly satisfactory in the writer's experience with high-temperature applications because of their tendency to stick and form polarized joints. It usually has been more satisfactory to use electrodes having a sealed-in mineral fibre, or a low resistance crack in the glass which permits a free flow of KCl. It has also been a matter of operating experience that reference electrodes of the ground-glass sleeve or plug type are more easily fouled than "pin-hole" junction cells when used in applications wherein a precipitate is formed and adheres to the electrodes. The pin-hole cell permits a free flow of KCl which, in most cases, tends to retard formation of a coating over the junction.

An unusual and perplexing source of electrode trouble has been in connection with the use of glass electrodes in amyl acetate solutions of penicilin broth. Some commercial glass electrodes have a top terminal insulator made of Lucite or similar material, and it has been observed that amyl acetate vapors "wet" the surface of this insulator and also the glass stem of the electrode, with a resultant shorting of the electrode measuring circuit. The use of insulating materials which do not "wet" by amyl acetate, and coating of the upper portion of the electrode with a resistant plastic cement, has eliminated this source of trouble in the application given. Other applications may have similar limitations and the control engineer should not overlook this condition as a possible source of trouble.

Newer techniques in electrode design and construction which are not within the scope of this discussion, have minimized many of the above-mentioned objectionable features and, although the application engineer must be guided by the limitations of available equipment, he can prolong the useful life and minimize operating errors of electrodes which are exposed to severe operating conditions, by rotating them on a periodic schedule with spares which are stored with the ends immersed in water (ordinary tap water) at room temperature. Rotation of three sets of electrodes on an eight-hour schedule has usually extended the useful life of electrodes beyond their continuous-service rating.

(To be continued)



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Vol. 4 — SEPTEMBER 1949 — No. 9

GENERAL NOTES

1. During the summer months, the local sections had no meetings so that no section reports appear in this issue.
2. As Mr. Hildenbrand has resigned as ISA Journal Editor, the National Office will fill in until the new editor is appointed. Therefore, be sure to send your news directly to the National Office, Instrument Society of America, 921 Ridge Avenue, Pittsburgh 12, Pa.
3. Beginning in this issue of the ISA Journal you will find two of the papers presented before the Fourth National Instrument Conference and Exhibit in St. Louis.
4. In the October issue you will receive a report on the St. Louis Board of Directors' Meeting.

WELCOME TO SECTIONS 46 AND 47

The 46th Section to be known as the Albuquerque Section has been granted a charter. Also section number 47, the Columbus Section has received notification of the granting of its charter. A hearty welcome to these two new sections.

ISA EMPLOYMENT SERVICE

In preparation for the coming months when the sections will again be holding their monthly meetings, the Employment Committee requests that the following suggestions be adapted to increase the efficiency of the Employment Service, and to expedite the handling of members' job applications.

Every section should have an Employment Committee. Appoint this Committee as early in the season as possible, if this has not already been done. Have the section Secretary or the Chairman of the Section Employment Committee advise the Chairman, National Employment Committee at the National Headquarters of the name and mailing address of the section Chairman. Suggested procedure for the operation of the Section Employment Committee will be sent to the section Chairman.

Every Section Employment Committee should immediately report to the National Office any opening for instrument men that cannot be filled from local section members. Every opening reported may mean a job for a member needing a position. In reporting the opening, give all requirements and the wage or salary if possible. Employment application forms will be provided all sections upon request. Have the member applicant fill in *all items* on the application card—this is important.

In order to provide more and better positions for members, the section Employment Committee can greatly assist the Employment Service by reporting to the National Office the names and addresses of those companies in the section area who employ instrument men. Also report the name of the individual in charge of employment if possible.

SECTION SECRETARIES AND MEETING DATA

	Telephone	*Date*	*Dinner*	*Meeting*
Akron: Fred Appel, 932 Columbia Ct., Barberton, Ohio.		4 Tues.	X	8:00
Aruba: A. S. MacNutt, c/o Lago Oil & Transport Co., Ltd., Aruba, N.W.I.		1 Tues.	X	7:15
Atlanta: H. Kockritz, Fischer & Potter Co., 84 Peachtree St., Atlanta, Ga.		4 Mon.	X	7:45
Baltimore: Geo. B. Greer, 631 E. 36th St., Baltimore, Md.		2 Fri.		
Baton Rouge: James H. Simpson, 3647 Gladiola, Baton Rouge, La.				
Boston: C. J. Nazzaro, 456 Central Avenue, Milton 87, Mass.		Last Wed.	6:00	7:00
California: D. D. Taylor, 234 E. Colorado, Pasadena 1, Calif.		1 Tues.	6:30	
Central Illinois: H. F. Lange, 2101 W. Glen Avenue, Peoria 5, Ill.		1 Wed.	6:30	7:30
Central Indiana: H. F. Coffey, 110 G Nelson Ave., Tyndall Towne, Indianapolis, Ind.		1 Tues.	X	7:30
Charleston: Albert H. Hix, 1529 B Dixie St., Charleston 1, W. Va.		1 Mon.	X	8:00
Chicago: Floyd E. Ertsman, Rm. 1420 Fisher Bldg., 343 S. Dearborn St., Chicago, Ill.		1 Mon.	6:30	8:00
Cincinnati: Edward H. Muhleisen, 320 Durrell Ave., Cincinnati 15, Ohio		3 Fri.	X	8:00
Cleveland: R. M. Woodside, Brown Instrument Div. of Minneapolis-Honeywell Reg. Co., 5005 Euclid Ave., Cleveland 5, Ohio.		4 Wed.	6:30	8:00
Cumberland: Clyde Babst, P.O. Box 447, Cumberland, Md.		Tues. after 4 Mon	6:30	8:00
Detroit: Seymour Sterling, 13331 Linwood, Detroit, Mich.		3 Tues.		
Eastern New York: Wm. J. Claffie, Winthrop-Stearns, Inc., 33 Riverside Ave., Rensselaer, N. Y.		1 Tues.	6:30	8:00
Gulf Coast: A. E. Bunn, 2237 North St., Beaumont, Texas.		3 Tues.		

	Telephone	Date	Dinner	Meeting
Houston: E. E. Kleir, 2518 S. Blvd., Houston 6, Texas.		Last Mon.	X	00
Inyokern, China Lake, Calif.: A. G. DeBell, U. S. Naval Ordnance, Test Sta., China Lake, Calif.				
Kansas City: Lewell F. Spies, J. F. Pritchard & Co., 908 Grand Ave., Kansas City, Mo.		Last Tues.	6:30	30
Louisville: H. C. Schermus, 980 Palarka Rd., Louisville, Ky.		4 Tues.	X	00
Montreal: L. J. Mizuhara, Monsanto (Canada) Ltd., 425 St. Patrick St., Ville LaSalle, Quebec, Canada.		Last Mon.	X	00
New Jersey: W. D. Archibald, 605 Westminster Ave., Elizabeth 3, N. J.		1 Tues.	6:00	
New Orleans: W. H. Haney, 2927 Music Avenue, New Orleans, La.		*No Regular Date*		00
New York: N. J. Cherry, P.O. Box 608, Merrick, N. Y.		Last Mon.	X	30
Niagara Frontier: Mrs. James L. Martin, 697 Potomac Ave., Buffalo 9, N. Y.	GR. 1450	4 Mon.	6:15	00
North Texas: F. Zapffe, Lone Star Gas Co., 2701 Logan St., Dallas 1, Texas.				
Northern Indiana: J. Baum Beckman, 547 N. Waller Ave., Chicago 44, Ill.		3 Wed.	6:30	7:30
Oak Ridge: John H. Clark, 138 Clayton Hall, Oakridge, Tenn.		1 Wed.	6:30	7:30
Ontario: John W. Huether, 311 Southerland Dr., Leaside, Ontario, Canada.		3 Thurs.	6:45	
Philadelphia: C. W. Wood, 6908 Market St., Upper Darby, Pa.		3 Wed.	X	8:00
Pittsburgh: Miss Louise Suckfield, c/o P.O. Box 2038, Pittsburgh 30, Pa.		4 Mon.	6:30	8:00
Presque Isle: Edwin P. Schuwerk, 445½ Halley St., L. P., Erie Pa.		4 Tues.	X	8:00
Richland: R. S. Hammond, 402 Abbott, Richland, Washington.		2 Wed.	X	7:30
Rochester: R. C. Swartz, Jr., 1201 Granite Bldg., Rochester 4, New York.		4 Tues.	X	8:00
St. Louis: W. G. Lee, 4710 Delor St., St. Louis 16, Md.		1 Wed.	X	8:00
Sarnia: Mr. Fred T. Yarke, 140 St. Clair St., Point Edward, Ontario, Canada.		2 Fri.	X	
South Bend: Sam M. Rouse, 436 Moccasin Ave., Buchanan, Mich.		1 Thur.	6:30	7:30
South Michigan: Homer Kuiper, 2517 Hillsdale, Kalamazoo, Mich.		2 Wed.	6:30	8:00
South Texas: H. C. Givens, La Gloria Corp., P.O. 637, Farfurrias, Texas.		1 Tues.	X	7:30
Tennessee: Nelson W. Taylor, 16 Edgewood, Kingsport, Tenn.		*No Definite Night*	7:00	8:00
Tulsa: C. R. Horton, 8211 E. 7th, Tulsa, Oklahoma.		1 Mon.	X	7:30
Twin Cities: Ray Hooper, International Div. Minneapolis-Honeywell Reg. Co., 2753 Fourth Ave., Minneapolis 8, Minn.		4 Tues.	6:30	
Washington: Edwin G. Brown, c/o American Instrument Co., 8010-20 Georgia Avenue, Silver Springs, Md.		3 Mon.	X	7:30
Wayne County: Robert Karr, 2455 Biddle Avenue, Wyandotte, Michigan.		3 Mon.	6:30	8:00

INSTRUMENTS ON THE MARCH — *Continued*

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"In general," continued Mr. Richards, "industrial instruments may be divided into two classes; steam-power specialties, and industrial process control. The former includes those instruments used primarily in connection with the generation and use of steam, and the latter those instruments used primarily in the chemical industry in the control of unit processes. . . . The steam-power specialties class of instruments requires training that applies particularly to power-plant control and the problems that are found in connection with the generation and utilization of steam. . . . Such training takes full advantage of the finest laboratory there is — his own industrial plant, power station, or chemical process.

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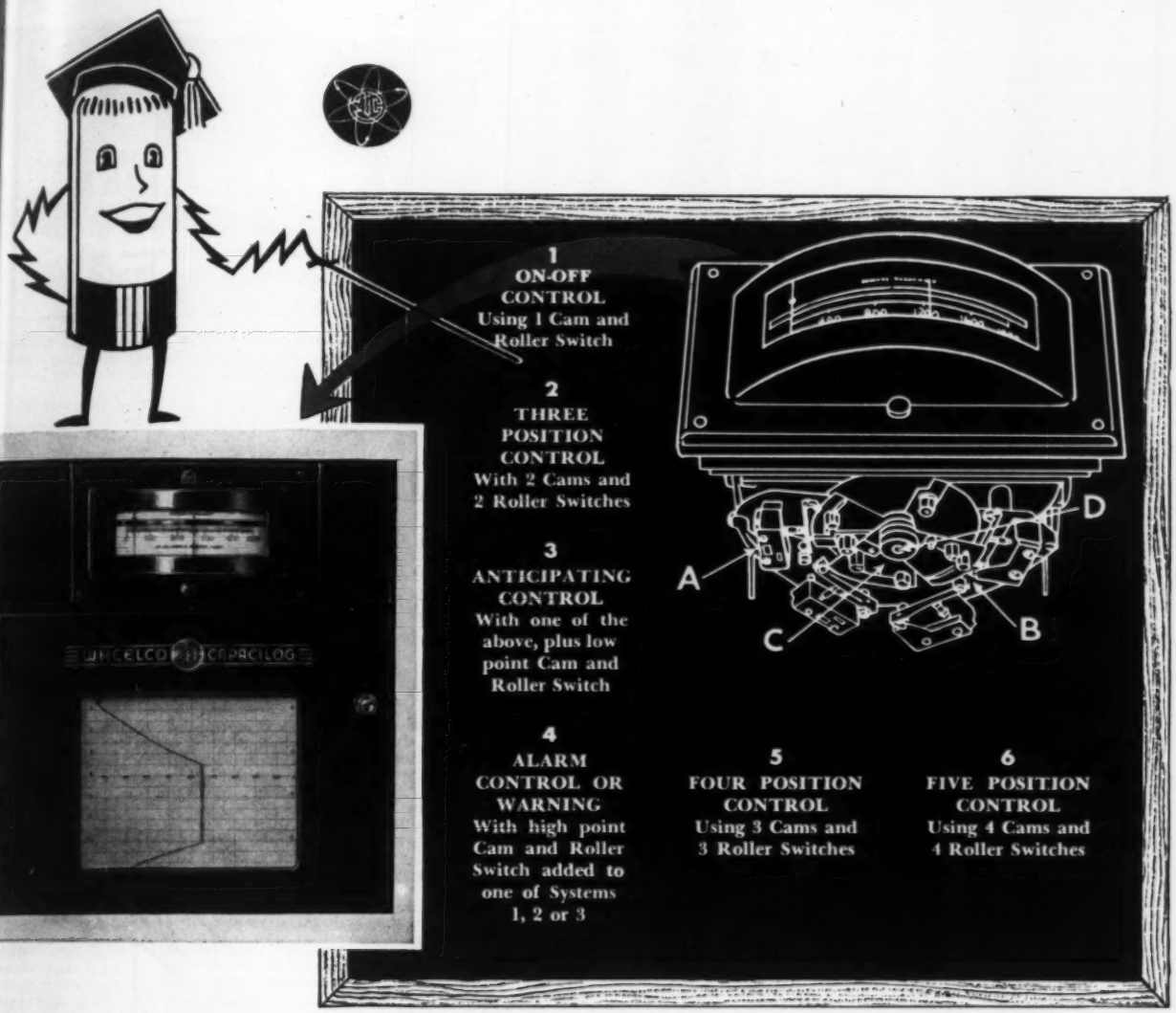

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from manufacturers. We urge readers to request ONLY those bulletins which will be of value to the Use the Postage-free Order Card on Page 863.

R-441 MAGNETIC COUNTERS. 2-page Bulletin No. G47-59C describes and illustrates maker's non-reset magnetic counters for a.c. or d.c. Standard specifications, optional features, etc. are listed.—Veeder-Root, Inc., Hartford 2, Conn.

R-442 MILLIVOLT METER. 4-page bulletin describes and illustrates maker's "Model MV-18A" RF vacuum tube millivolt meter for TV, FM, and radar. Applications, frequency response, specifications, etc. are discussed.—Millivac Instruments, P. O. Box 3027, New Haven, Conn.

R-443 "RECTIFIER NEWS." 4-page issue of this house organ discusses selenium and selenium dry plate rectifiers.—International Rectifier Corp., 6809 South Victoria Ave., Los Angeles 43, Calif.

R-444 MOISTURE CONTENT INDICATOR. 10-page bulletin describes and illustrates maker's "Drimeter" instrument which can be installed in any type fabric or warp sizing machine to indicate moisture content of finished product.—Fielder Electronics, Inc., Huntington, Long Island, N. Y.

R-445 PAPER TESTING. 2-page Bulletin 4905 presents discussion titled: "What's New In Paper Testing Instruments."—Thwing-Albert Instrument Co., Pulaski Co., Pulaski Ave. at Penn St., Philadelphia 44, Penna.

R-446 "THE HYDROMIKE." 4-page No. 31 issue of this house organ covers information on instrumentation in hydrology, surveying, and meteorology. Discussion of "Robot River Reporter," a device for signalling water level readings over telephone, is featured.—Leupold & Stevens Instruments, 4445 N.E. Glison St., Portland 13, Ore.

R-447 AIR GAGES. 26-page Catalog CTP-491 describes and illustrates maker's "Precisionaire" instrument for dimensional control problems. Features, components, special applications, etc. are discussed.—Sheffield Corp., Dayton 1, Ohio.

R-448 D-C. AMPLIFIER. 2-page bulletin describes and illustrates maker's "Type DCA-3" universal d-c. amplifier equipped with widely variable input and output circuits, adjustable gain and feedback. Features, applications, vacuum tube voltmeter operations, calibration, accuracy, etc. are discussed.—Millivac Instruments, P. O. Box 3027, New Haven, Conn.

R-449 CHRONOGRAPHS AND TIME STANDARDS. 16-page Bulletin 171-49 illustrates and describes maker's tape chronographs, drum chronographs, electrically driven tuning forks, regulator clocks and accessories.—Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago 14, Ill.

R-450 OSCILLOGRAPH PHOTOGRAPHY. 12-page booklet describes oscillograph photography with maker's "Oscillo-Record" camera. Oscillograms produced, specifications, accessories, etc. are discussed.—Fairchild Camera and Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

R-451 HAND CONTROL VALVES. 20-page Bulletin No. 241-1 illustrates and describes maker's "Hi-Lift V-Port Indicating Type Hand Control Valves." Also contains information on determining valve sizes, capacity charts for liquids, air, gases, and steam.—Minneapolis-Honeywell Regulator Co., Brown Instrument Div., Wayne and Roberts Aves., Philadelphia 44, Pa.

R-452 "THE OSCILLOGRAPHER." 4-page Vol. 11, No. 2 issue of this house organ features articles titled: "Luminescent Screens for Cathode-Ray Oscillography," and "Diode Limiter Circuits in Oscillographis Applications."—Allen B. Dumont Laboratories, Inc., Instrument Div., 1000 Main Ave., Clifton, N. J.

R-453 LABORATORY APPARATUS. 32-page Catalog 860 describes and illustrates maker's apparatus for metallurgical laboratories; includes description of "Polmatic" automatic polisher for polishing specimens for microscopic examination; hand model specimen polisher; submerged specimen cutter; and accessories.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

R-454 LABORATORY OVENS. 28-page Manual No. 397 describes and illustrates maker's laboratory temperature control apparatus; features design, gravity and mechanical convection, construction, insulation, wiring. Models described include cabinets for handling inflammable or explosive material, steam-heated ovens, incubators, etc.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

R-455 "BURRELL ANNOUNCER." 16-page No. 49-6-35 issue of this house organ features a historical story titled "Filter Paper;" and articles on new refractometer, speed drying oven.—Burrell Technical Supply Co., 1942 Fifth Ave., Pittsburgh 19, Pa.

R-456 DIAPHRAGM CONTROL VALVES. 32-page Bulletin 700-1 describes and illustrates maker's "Series 700" diaphragm control valves; includes diagrams, drawings, charts and tables on air-operated diaphragm motor control valves.—Belfield Valve Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

R-457 LIQUID LEVEL CONTROLLERS. 32-page Bulletin 48-1 pictures and describes maker's direct-connected and air actuated controllers for controlling, maintaining and regulating liquid levels; includes tables and charts.—Belfield Valve Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

R-458 BROADCAST STATION MEASUREMENTS. 38-page manual explains and illustrates station performance measurements required by F.C.C. records and reports; designed to assist radio engineers meet requirements for AM and FM broadcasters; lists equipment needed, proper procedure for measuring, recording, etc.—Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.

R-459 "GENERAL RADIO EXPERIMENTER." 8-page Vol. XXIV No. 1 issue of this house organ features an article titled "Distortion Measurement in the Broadcasting Station."—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

R-460 TRANSMITTER MICA CAPACITORS. 2-page Bulletin No. NB-135 describes and illustrates maker's new line of transmitter mica capacitors with universal mounting intended for use in low power transmitters; lists dimensions, outstanding features and uses.—Cornell Dubilier Electric Corp., South Plainfield, N.J.

R-461 ELECTRONIC GAGER. 8-page bulletin describes and illustrates maker's "Varec" electronic gager, remote reading liquid level gage; lists features of transmitter and receiver units, wiring, diagrammatic installations, etc.—Vapor Recovery Systems Co., P.O. Box 231, Compton, Calif.

R-462 CORROSION-RESISTANT MATERIALS. 4-page bulletin, Catalog Section 97, tabulates corrosion-resistant materials of construction and packing materials for use with over 300 industrial liquids and gasses.—Fischer and Porter Co., 97 County Line Rd., Hatboro, Pa.

R-463 "TRACERLOG." 12-page No. 19 issue of this house organ contains articles on new equipment, uses of radioisotopes and a list of recently published books in the field of radioactivity. —Tracerlab, 55 Oliver St., Boston 10, Mass.

R-464 CHLORINIZER. 4-page Bulletin 840-S describes and illustrates maker's "Model 7S" Chlorinizer; also contains distinguishing features, uses, construction and installation information.—Builders-Providence, Inc., Providence 1, R. I.

R-465 MEASUREMENT OF RADIOACTIVITY. 30-page RCL Information Bulletin No. 5 describes and illustrates maker's instruments for detection of radioactivity. — Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill.

R-466 DIAL THERMOMETERS. Bulletin 5 describes maker's vapor-pressure-actuated dial thermometers; uses for rigid stem or flexible tube type.—The Powers Regulator Co., 2720 Greenview Ave., Chicago 14, Ill.

R-467 RECORDING THERMOMETERS. Bulletin No. T842 describes and illustrates uses of maker's traveling-oven recording thermometer; lists specifications.—The Bristol Co., Waterbury 20, Conn.

R-468 TIME CALIBRATOR. 2-page bulletin describes and illustrates maker's "Type 160" oscilloscope time calibrator; lists uses and specifications.—Owen Laboratories, 9130 Orion St., San Fernando, Calif.

R-469 REGULATED POWER SUPPLY. 2-page bulletin illustrates and describes maker's "Model A" regulated power supply; lists regulation, ripple, stability, dimensions, weight and uses. —The Howard Co., 934 Argyle Rd., Drexel Hill, Pa.

R-470 FEED WATER CONTROL. 16-page Bulletin No. 105-B describes and illustrates maker's three-element feed water control; explains advantages, control problem, operating features; lists users.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

R-471 TEMPERATURE CONTROLLERS. 4-page Bulletin No. 340 lists and illustrates maker's control instruments; includes specifications and prices on low- and high-pressure throttling valves controls, dial thermometers, temperature recorders, etc.—The Partlow Corp., New Hartford, New York.

R-472 MAGNETIC PENMOTOR. 2-page bulletin describes and illustrates maker's model BL-902 magnetic recording penmotor, and model BL-905 amplifier for use with penmotor; lists uses and specifications.—The Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.

R-473 ELECTRIC FURNACE. 4-page Bulletin No. 515 describes and illustrates maker's high-temperature electric furnaces; gives essential features and specifications.—Burrell Technical Supply Co., 1942 Fifth Ave., Pittsburgh 19, Pa.

R-474 "MODERN PRECISION." 4-page Vol. 9, No. 1 issue of this house organ features articles on waste neutralization and better control of furnace firing through use of maker's products. —Leeds & Northrup Co., 4902 Stenton Ave., Philadelphia 44, Pa.

R-475 DIAPHRAGM SEAL FOLDER. 2-page Drawing No. GH-449 depicts maker's plain and cleanout type diaphragm seals, for insertion in maker's Diaphragm Seal File Folder.—Mansfield and Green, Cleveland, Ohio.

R-476 COLOR MATCHING APPLICATOR. 4-page bulletin illustrates and describes maker's "Triplex Film Applicator" for matching colors and comparing gloss and opacity; treats matching problems, operation and cleaning of instrument.—Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md.

R-477 MAGNETIC OSCILLOGRAPHS. 2-page bulletin illustrates and describes maker's model BL-202 double-channel magnetic oscillograph and model BL-211 single-channel with amplifier; lists uses and specifications.—The Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.

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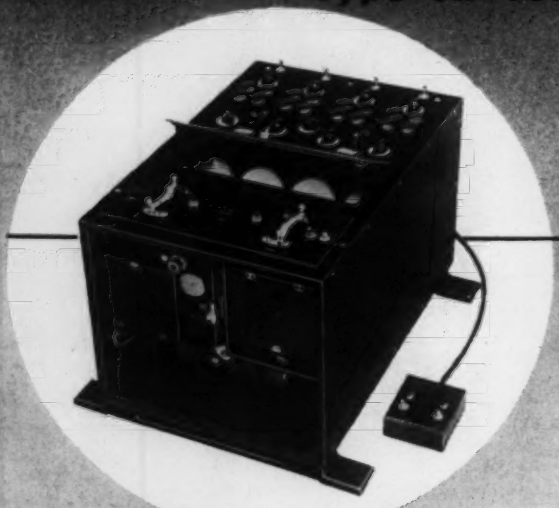

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R-478 **FLAME PHOTOMETER.** [illegible] page Instruction Manual describes and illustrates [illegible] maker's "Model 52A" flame photometer; contains [illegible] diagrams; treats installation, operation, [illegible] performance, etc.—The Perkin-Elmer Corp., [illegible] Conn.

R-479 **STRENGTH TESTERS.** [illegible] page catalog describes and illustrates maker's [illegible] bursting strength testers, micrometers, basis weight scales for manufactured or fabricated materials; lists uses, specifications.—E. J. Cady Co., [illegible] N. La Salle St., Chicago 2, Ill.

R-480 **STRAIN AMPLIFIER.** 2-page bulletin describes and illustrates maker's model "B-310" strain amplifier; lists uses and specifications; use with direct inking oscillograph.—The Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.

R-481 **AIR FILTERS.** 2-page Bulletin PF-1 illustrates and describes maker's absorptive air "Centrisorb" air filters; lists dimensions and capacities. — Industrol Corp., 88-35 76th Ave., Glendale, Brooklyn 27, N.Y.

R-482 **SYNCHRONOUS MOTORS.** 8-page Catalog IS-100 describes and illustrates makes of small synchronous motors and instrument movements; contains complete data, cutaway views, specifications and typical applications.— Telechron Inc., Ashland, Mass.

R-483 **PHOTOMETRIC UNIT.** 8-page brochure describes and illustrates maker's photometric unit and exposure heads; contains instructions, applications, installation, operation and maintenance data.—Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md.

R-484 **PORTABLE GLOSSMETER.** 4-page booklet illustrates and describes maker's portable 75-degree glossmeter for testing paper and other materials.—Henry A. Gardner Laboratory, Inc., 4723 Elm St., Bethesda 14, Md.

R-485 **TIMING DEVICES.** 6-page catalog "Mark-Time" illustrates and describes makers' timers and switches; lists uses and specifications.—M. H. Rhodes, Inc., 30 Bartholomew Ave., Hartford 6, Conn.

R-486 **REGULATING VALVES.** 24-page Bulletin No. 10-1 illustrates and describes makers' regulating valves for water, steam, air, gas or oil; float valves; contains cutaway views, diagrams, price lists and dimensions.—Belfield Valve Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

R-487 **HIGH-VACUUM APPARATUS.** 52-page revised Bulletin 10A describes and illustrates maker's vacuum pumps and accessories; contains data on high-vacuum systems, uses and specifications of instruments.—Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

R-488 **"EBERBACH ANNOUNCER."** 16-page No. 49-6-35 issue of this house organ features articles on filter paper, portable autoclave, speed drying oven.—Eberbach & Son Co., Ann Arbor, Mich.

R-489 **ELECTRONIC INSTRUMENTS.** 32-page Bulletin 427 describes and illustrates maker's "Dynalog" electronic instruments for process measurement and control; explains principle of operation; contains chart records, drawings and photos, specifications and applications.—The Foxboro Co., Foxboro, Mass.

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R-490 SELENIUM RECTIFIERS. Two 2-ge bulletins describe and illustrate maker's tron "Powerector" bridge rectifiers; contains arts and specifications. — Standard Arcturus rp., 54 Clark St., Newark 4, N. J.

R-491 STRIP SELENIUM RECTIFIERS. age bulletin pictures and describes maker's lf-wave strip and half-wave stack rectifiers; ntains charts and specifications.—Standard Arcrus Corp., 54 Clark St., Newark 4, N.J.

R-492 THERMOCOUPLE MANUAL. 40-ge Bulletin T/C 7 describes and illustrates mak-'s thermocouples, their construction and uses; tains drawings, charts, price lists.—Wheelco strument Co., Chicago 7, Ill.

R-493 "THE C-D CAPACITOR." 16-page l. 14 No. 6 issue of this house organ features icle titled "Voltage-Regulated Power Sup-es;" continues "Radio Trading Post" section. Cornell Dubilier Electric Corp., Hamilton vd., South Plainfield, N.J.

R-494 LABORATORY VOLTAGE DI-DER. 2-page Bulletin 106 describes and illus-tes maker's wide-range "potentiometer-rheostat" laboratory, experimental use; lists applica-ns, specifications, stock values. — The Helipot rp., South Pasadena, Calif.

R-495 LOW-TEMPERATURE-MELTING LOYS. 4-page Bulletin J4-6-49 describes mak-'s alloys, their characteristics and applications; s known uses.—Cerro de Pasco Copper Corp., pt. CAC, 40 Wall St., New York 5, N.Y.

R-496 BATTERY ELIMINATORS. 4-page lletin describes and illustrates maker's "Recti-ers," their use and advantages in telephone in-stry; list specifications. — Raytheon Mfg. Co., altham 54, Mass.

R-497 FB REGULATING VALVES. 24-page lletin No. 47-1 illustrates and describes "Type B" single-seat fully-balanced regulating valves, ts dimensions, uses; contains flange dimension d circumferences and areas of circles charts.— elfield Valve Div., Minneapolis-Honeywell Reg-ator Co., Philadelphia 44, Pa.

R-498 WIDE-RANGE OSCILLATOR. 4-ge bulletin pictures and describes maker's low-stortion wide-range "Model M" oscillator; lists es and specifications, diagrammatic drawing.— outhwestern Industrial Electronic Co., 2831 Post ak Rd., Houston, Texas.

R-499 "THE OHMITE NEWS." 2-page May-une issue of this house organ features articles on lax Planck, and one titled "Wattage and Current elation in Resistors."—Ohmite Mfg. Co., 4835-1 Flournoy St., Chicago 44, Ill.

R-500 RECORDING INSTRUMENTS. 16-ge booklet, "Solving Industrial Crimes — Case o. 37," describes and illustrates maker's re-orders, stresses reduction of waste.—The Ester-ne-Angus Co., Inc., Indianapolis, Ind.

R-501 "ELECTRONIC PNEUMATIC ME-

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HANICAL INSTRUMENTATION." 32-page ol. 4 No. 1 issue of this house organ features ticles titled "Precision Heat Treating at Landis ool Company," "Progress Parade of Process In-rumentation," and others.—Brown Instruments iv., Minneapolis-Honeywell Regulator Co., ayne and Roberts Aves., Philadelphia 44, Pa.

R-502 LABORATORY HEATING JACK-TS. 12-page bulletin describes and illustrates aker's heating jackets with safety thermostats; t features, uses, dimensions.—Scientific Glass pparatus Co., Inc., 49 Ackerman St., Bloom-ld, N.J.

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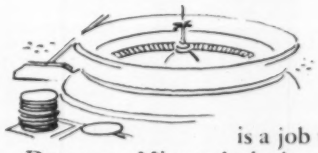

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